CHEMISTRY

APPLIED TO

ARTS

AND

MANUFACTURES.

BY M. J. A. CHAPTAL,

MEMBER AND TREASURER OF THE FRENCH SENATE;
GRAND OFFICER OF THE LEGION OF HONOUR;
MEMBER OF THE NATIONAL INSTITUTE;
HONORARY PROFESSOR OF THE SCHOOL
OF MEDICINE, &c. &c. &c.

IN FOUR VOLUMES.

VOL. II.

LONDON:
PRINTED FOR RICHARD PHILLIPS,
No. 6, Bridge-street, Blackfriars.
1807.
By J. Adlard, Duke-street

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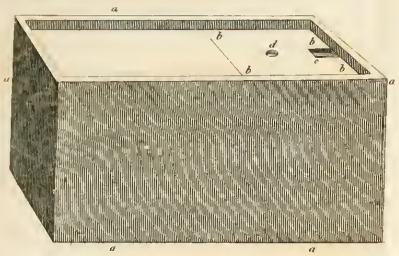
Fig 1



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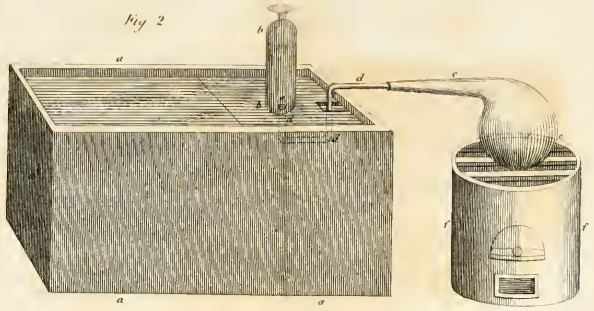

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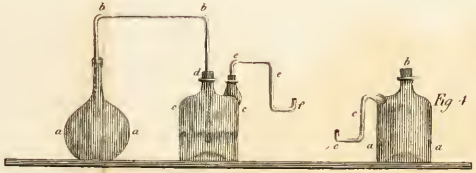
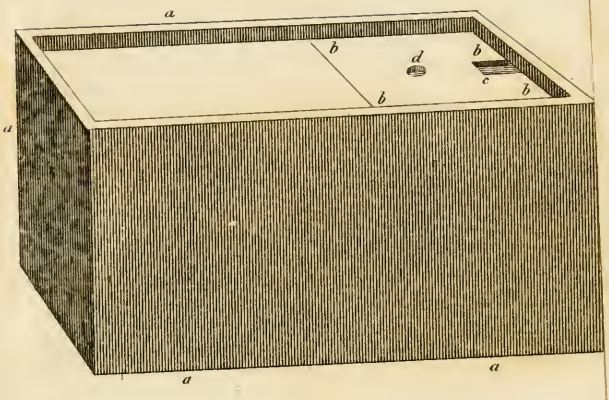


Fig 4

Published June 1, 1817, by R. Phillips, Bridge Street Blackfriars London

Fig 1



EXPLANATION OF THE PLATE

TO THE

SECOND VOLUME.

FIGURE I. represents a hydro-pneumatic trough.

a a a, Sides of the trough.

b b, Floor of the trough.

c, A hole made in the floor to afford a passage for the tube.

d, Aperture in the middle of the floor, to which the end of the tube comes.

FIGURE II. represents a hydro-pneumatic trough, with an apparatus for a retort, at the time of the experiment.

a a a, Sides of the trough.

b b, A glass inverted upon the floor, intended to receive the gases.

c c, The retort on a furnace.

d d, A tube adapted to the retort, and conducting the gases under the floor.

f f, The furnace.

FIGURE III. represents a phial provided with a tube.

a a, The phial.

b b, A curved tube adapted to the phial, and conducting the gases into the water in a flask.

c c, The flask.

d, Tubulure of the flask, with a cork stopper.

e e, Curved tube adapted to flask, for the purpose of conveying the vapour under the floor of a hydro-pneumatic machine.

f, Curved end of the tube,

FIGURE IV. represents a tube with a curved end.

a a, Body of the flask.

b, Tubulure of the flask.

c c, Curved tube attached to the flask.

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CHEMISTRY

APPLIED TO THE ARTS.

PART II.

Of those Bodies which are the Subjects of Chemical Action.

ALL bodies undoubtedly exert, with greater or less force, a reciprocal chemical action; but we can obtain a competent knowledge of it only by recurring to their elementary principles, in order to examine separately, and with care, the particular action of each element.

By these means, as simple as they are natural, the chemist places in his hand, and under his view, the subjects of chemical action: he studies the character and properties of each; he

presents them in succession one to the other, in order to determine the action, and he obtains at length results, which may be regarded as the principles of all the operations of nature and of art, and as the true bases of chemical science.

This procedure has the further advantage of presenting to us the bodies in that state in which their affinities exert the highest degree of energy; for in proportion as they are reduced to their elementary state, they recover by degrees all the power they had lost in their combinations.

We shall commence by treating of the gaseous fluids as the most simple, and afterwards proceed to the other substances, as well liquid as solid, which constitute the principal agents in chemical action.

CHAPTER I.

Of Gaseous Fluids.

IN treating of the properties of caloric, we have already remarked, that this fluid expands all substances, and that some have an affinity for it so strong, that they are entirely dissolved at the temperature of the atmosphere, and constantly present themselves to us in the state of invisible and aeriform fluids: these are what we denominate *gaseous fluids*, *gas*, &c.

The gases are essentially different from substances in the form of steam, or vapours, whether they be visible, or whether they elude our view; for the latter substances resume their primitive state, at the moment when the caloric, which converts them into vapour, abandons them to expand itself among surrounding bodies of lower temperature, while the gases preserve their permanent form, whatever degree of variation the atmosphere may undergo.

It is to the knowledge of these gaseous sub-

stances, respecting which the ancients had but very imperfect notions, that modern chemistry is indebted for almost all its advances. This will cease to astonish, if we reflect, that these gaseous matters which press upon the globe at every part, are the agents in almost all the operations of nature; that they enter into combination with most substances, and that they disengage themselves at every change by which these substances are affected; so that the atmosphere and the earth are in a state of perpetual interchange of principles, of action and re-action.

The discovery of these various gases has unfolded to the chemist a new *mode of existence* in substances: it has shewn him, that the enormous mass called the atmosphere, is a composition or admixture of principles, as different from each other as are liquid or mineral substances, and that they have no properties in common but their invisibility.

At this period can chemistry first be said to date its origin: hitherto the combinations of air were unknown; the gases which were disengaged in our processes, or in spontaneous decompositions, could neither be detected nor

appreciated; so that the analyses were all imperfect; and the chemist, acquainted with one part only of the agents of nature, of course indulged himself in all the delusions of conjecture.

When at the present day we review the simplicity of the means employed to extract and analyze the gases, we stand amazed that our predecessors should not, by anticipation, have wrested from us these discoveries. Indeed this sentiment is always excited by discoveries of the highest order; for they present themselves to us with such simplicity, that every person is astonished that he himself was not the author.

The apparatus, gradually brought to perfection, which is used in laboratories for experiments on gases, consists of a trough of wood lined with thin sheet-lead, usually of an oblong form, about eighteen inches in depth and in length, (see Fig. 1, Pl. I.) At about three inches from the upper edge, and at one end, are worked two grooves, into which is passed a shelf of wood *b b*, the inferior surface of which is excavated towards the middle, and in the centre of this excavation is pierced the hole *c*.

This shelf contains also two orifices at the sides *d d*, in order to admit the bent ends of the tubes which transmit the gases.

In order to conduct operations with the aid of this trough, it must be filled with water so far as to cover the shelf; and over the hole in the centre of the shelf, are placed glass vessels inverted and full of water. The tubes which conduct the gases, enter by their bent extremities one of the lateral orifices *d d*, so that their mouths open in the excavation formed under the shelf, (see Fig. 2. Pl. I.); the bubbles of gas then pass through the hole *c* of the shelf, and rise in the inverted jar; as they rise the water descends, and the jar is at length filled with the gas. It is then slided to the side of the shelf, and received upon a plate of glass, which is adapted so perfectly to the edges of the jar, as to prevent alike the escape of the gas or the entrance of the atmospheric air. Afterwards the gas may be passed into phials, which it is requisite to cork when full, in order to preserve and afterwards submit it to the various tests which may indicate its nature and characters.

When the action of fire is necessary to the

disengagement of the gases, the tubes of which we have spoken (Fig. 3, Pl. I.), are generally adapted to retorts, or to small medicine phials. But when the gases disengage themselves at the common temperature, as is the case when diluted sulphuric acid is poured upon carbonate of lime, to extract the carbonic acid, a flask with a bent neck may be employed, (see Fig. 4, Pl. I.)

The apparatus for the gases is known by the names Pneumato-chemical, (or often simply Pneumatic), and Hydro-pneumatic Apparatus, &c. The gases to be extracted are frequently, from their nature, soluble in water; such, for example, are the acid and ammoniacal gases. In these cases a smaller apparatus is used, and mercury is substituted for water. This property of solubility in water, which some of the gases possess, has furnished the means of procuring ammonia and some of the acids with greater economy and ease than were formerly practised; for by receiving these gases in a well proportioned quantity of water, the products are obtained in a degree of purity and concentration very difficult to be procured by the ancient practice of distillation.

As the pneumato-chemical apparatus is at present an object of the first necessity in a laboratory, much study has been employed to render it of more convenient use; and I have not hitherto seen any one which offers more advantages than the one represented by Fig. 1, Pl. II. On a level with the shelf, and at the distance of about ten inches, a large platform or plane is fixed, on which are arranged the vessels necessary to receive the gases: below this plane is left a void space, highly serviceable as a receptacle for whatever may be used in these kinds of operations. The whole depth of the trough is free only in the space included between the plane and the opposite edge, which space is sufficient to permit the filling of vessels of the largest diameter and of the greatest height. This construction requires the smallest quantity of water; the oscillations of this liquid are almost entirely prevented; yet as many vessels may be filled as in any other apparatus, because the plane is on the level with the shelf, and only that portion of water which is above this level can be employed in filling the jars.

The gases are not always in that state of com-

bination from which distillation, or the power of re-agents, are necessary to extract them; they are often found free and disengaged from all obstacles: in this case they are collected by emptying in their atmosphere a flask or bottle of pure water: these vessels are occupied by the gas as the liquid escapes; they are next carefully closed, in order to transport them to the laboratory, where the gases they contain are subject to suitable experiments. In this manner it is possible to collect the air of caverns, the gases of fermentation, and the air of a theatre, &c.

SECTION I

Of Oxygen Gas.

OXYGEN, on account of its importance, claims the first notice: it is the aliment of respiration, of combustion, and of oxidation; there are few phenomena in nature, or in the arts, on which this gas has not some influence.

This gaseous substance was discovered by the celebrated Priestley, on the 1st of August, 1774.

Nature does not, in any instance, produce the oxygen gas in absolute purity : it is always mixed or combined with other substances, from which it must be extricated.

We are acquainted with three methods of extracting it ; 1*st*, By the action of heat ; 2*d*, by that of light ; 3*d*, by that of the acids.

1*st*, Oxygen enters into combination, with more or less facility, with all the metals ; it deprives them of their metallic properties, and transforms them into oxides, (the *metallic calx* of the old chemists).

In order to disengage the oxygen of the oxides, it is sufficient, in some instances, to raise the temperature by the application of heat. The oxygen is separated in the state of gas, and the metal re-appears with all its metallic forms and properties. If the operation be performed in a retort, and the product be received in the hydro-pneumatic apparatus, the oxygen gas and the metal are obtained separately.

Those metals which are the most difficult to oxydize, part with their oxygen with the greatest facility. Platina, gold, silver, mercury, and manganese, belong to this class. The other metals contract with oxygen an union so firm,

that to effect a separation, it is necessary to present to the oxygen some body with which it has a powerful affinity; for this purpose carbon is used, and its action aided by heat.

By decomposing the oxy-muriate and the nitrate of potass by distillation in a retort, the oxygen gas may be extracted in great purity, and be collected in the hydro-pneumatic apparatus.

2*d*, Light concurs powerfully in disengaging oxygen from some of its combinations.

A phial of oxygenated muriatic acid exposed to the sun, gives out all the superabundant oxygen it contains, and passes into the form of common muriatic acid. The same acid is preserved from decomposition in a phial well covered by black paper, although it be exposed to the sun, or to heat in a dark place.

But of all the phenomena which occur in the emission of vital air by the agency of light, no one is more striking than the production of this gas by vegetables. In the year 1775, Ingenhouz published his experiments, which he considered as proofs that plants transpire pure air in the light of the sun, and a mephitic gas in the shade. Mr. Sennebier confirmed the first

result, and denied the second: his work appeared in 1782.

In order to witness this phenomenon, we have only to place a living plant in water, and expose it to the clear light of the sun: small bubbles are observed to form themselves on the leaves; they ascend and burst at the surface of the water, and may be collected by receiving them in an inverted jar. These bubbles consist of oxygen gas, of a greater or less degree of purity.

M. Sennebier, who has made a long series of interesting experiments on this subject, observed, that water rendered slightly acidulous, facilitated the extrication of the gas, and increased the quantity of it; that it is only the green parts of the plants which produce it; that less of it is afforded by young leaves, than by leaves of full growth; that the emission of gas takes place more or less rapidly, according to the nature of the vegetables, &c.

The *Confervæ* yield largely the vital air, as does also the green matter which is formed under water, and which Ingenhouz supposed to be an assemblage of insects.

3*d*, Oxygen gas may be also procured by

disengaging it from its combinations, by means of the sulphuric and other acids which are but moderately volatile. The black oxide of manganese is usually employed for this purpose, known in commerce by the name of Glass-makers' Soap. A retort may be used, and the distillation performed with the hydro-pneumatic apparatus; but I use in preference, a common phial, with the neck ground and bent. The oxide should be carefully pounded and put into the phial; concentrated sulphuric acid is then poured upon it, to form a liquid paste. The bent tube (Fig. 2, Pl. II.) is next employed; a stopper of cork, pierced by a hot iron, is exactly fitted to the branch *a*, and the phial is closed by the tube, (Fig. 3, Pl. II.); the mouth *c* is passed beneath the shelf of the hydro-pneumatic apparatus, and the action of the acid is aided by the application of heat to the phial. This very simple apparatus serves for many other operations, and possesses the advantage of allowing the chemist to observe whatever takes place during the process, and of being equally favourable to expedition and to economy.

Oxygen gas is somewhat heavier than com-

mon air. The cubic foot of this gas weighs 587.52 grs. English, according to Kirwan; and the cubic foot of atmospheric air 535.68, grs. English. According to the calculations of this chemist, its weight is to that of common air as 1103 is to 1000.

The specific gravity of pure air, compared with that of water, is 13.3929; that of common air is 12.3233, according to Brisson.* The same naturalist found that a cubic inch of pure air weighed 0.5000 grs. (0.4977 grs. English), whilst one of common air weighed 0.4600 grs. (0.4579 grs. English); and that the cubic foot of the first weighed 1 oz. 4 grs. (709 grs. English), and of the latter 1 oz. 3 gros, 3 grs. (660 grs. English).

Oxygen appears to be the only gas capable of supporting combustion; and this acknowledged fact induced Scheele to denominate it *fire air*.

In order to proceed regularly on a subject of such nicety as that of *combustion*, it appears proper to begin by fixing our ideas of the import of this term.

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* Instead of the English standard of 1,000, that of 10,000 is used. T.

Men in general include in their meaning of the word combustion, nothing more than the phenomena which are observed in our hearths, which constantly produce flame, heat, and light. The chemist more rigorous in his acceptation of the term, denominates *combustion* every operation which occasions the fixation and combination of oxygen.

In numerous instances in which light and heat fail to impress our senses, we are by no means authorized to reject their existence, or to deny their production: it is a fact, that oxygen gas cannot enter into combination without liberating a portion of the caloric which held it in the form of gas. If the combustion of a certain weight of iron be effected by a sufficient quantity of oxygen, in the interval of a minute, or in the space of a month, the effect will be the same: but, in the first case, the combustion will be accompanied by a very perceptible disengagement of heat and light; whilst, in the second, the quantity of heat and light, being extended through all the instants of a very long interval, will not produce, at any time, an impression capable of affecting our senses. It is for a similar reason that phosphorus, burnt at

a temperature of 122, produces heat and flame, whilst the combustion which is insensible, and proceeds slowly at the temperature of the atmosphere, and in a tranquil air, gives, it is true, the same product, but the phenomena differ in this, that, in the latter instance, neither heat nor light are perceptible.

In all cases, and in all operations which occasion the fixation or assumption of the concrete form of the oxygen gas, there is a production of heat, and probably of light; but heat and light are imperceptible to us, unless they be disengaged in large quantity in a short space of time; they are incapable of impressing our senses during their slow production.

The products of combustion, or of the fixation of the oxygen gas, vary, according to the nature of the body with which it combines: a great number of these combinations assume the character of acids.

The combustion of vegetable substances by oxygen, causes the formation of water or of carbonic acid, according to the combination into which it enters, whether it be with hydrogen or with carbon.

In fermentations and decompositions, whe-

ther of animal, vegetable, or mineral substances, oxygen is still the principal agent. In all these cases, it is furnished by the atmosphere or by the decomposition of water. In one instance it unites with carbon, and is disengaged in carbonic acid gas, and occasions the predominance of hydrogen, as in vinous fermentations; in other instances, it combines with hydrogen and carbon, and forms the acids. In the mineral kingdom, it oxidizes the metallic particles, and disunites the mass; it combines with sulphur, which is found in union with several metals, causes the formation of sulphuric acid, and produces the sulphates.

Oxygen produces the phenomena of combustion not only in its gaseous state, but in many cases also where it is in combination, it transfers itself to combustible bodies which are presented to it, and burns them: the nitrates and oxy-muriates, which we decompose by carbon, furnish proofs of this.

The combustion of oils by the decomposition of the nitric acid, has long been known. Chemistry has derived great advantage from this property, by transferring the oxygen of the nitric acid to other bases, such as arsenic, mo-

lybdena, phosphorus, camphor, and sugar, in order to form acids, &c. Our contemporaries M. M. Westrumb, Scheele, and Berthollet, have succeeded in burning in the oxygenized muriatic acid gas, phosphorus, sulphur, camphor, oils, alcohol, and the larger part of the metals.

This new kind of combustion is, properly speaking, nothing more than displacing the oxygen by a combustible which has a greater affinity to it than that has to which it is united.

3*d*, Another not less striking property of oxygen gas, is that of its being the only one adapted for respiration;* and on account of this

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* About twenty years ago, two celebrated chemists, Bergman and Scheele, maintained, that hydrogen gas was respirable. This position was disputed by Morozzo and Fontana. This difference of opinion in four distinguished men, appeared to me to have its source in an erroneous manner of considering respiration. That a gas may be received into the lungs, and then exhaled without danger to the individual, does not entitle it to the appellation respirable: it is further necessary that it be decomposed in this organ, and undergo a real digestion: without this the air, which only enters the lungs without alteration, may be compared to those grains of sand which pass through the stomach without danger; but no one has, on this account, thought himself authorized to class them among our aliments: this is the case with respect

eminent quality, the celebrated historian of the Academy of Sciences, Condorcet, named it *vital air.*

All animals, without exception, respire vital air; M. Vauquelin has proved that it is necessary to insects and worms: but all animals do not require the same purity of air; the birds as well as man, require it more pure than animals which are torpid during the winter: the red snail, and that found on vines, separate completely the oxygen from its admixture with the azotic gas and carbonic acid, nor do the latter cause them any inconvenience. (*Observations on the Respiration of Insects and Worms*, read at the Academy of Sciences, September 17, 1791.)

The organ which serves for respiration, is more or less perfect, and more or less guarded against all hurt from external bodies, according to its importance in the different classes of animals. It is inclosed in the centre of the body,

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to hydrogen and some other gases; the lungs may be filled with them repeatedly without inconvenience, but they suffer no change: the most we can infer from this is, that they are not poisons.

and preserved by an osseous frame from the injurious action of external bodies, in the instances of birds, man, and almost all quadrupeds; whilst in amphibious animals, it is little more than a membrane or a kind of purse, expanding almost out of the body, suffering dilation and contraction; so that this class of animals can, for a considerable time, suspend their respiration, as I have proved respecting frogs; nor do they at all require the same purity of air which is necessary for other animals. Insects with trachææ present to us organs of respiration distributed along the body, accompanying all the vessels, and degenerating into imperceptible pores. These trachææ in some instances have a communication with the stomach: M. Vauquelin has observed this communication in the grasshopper, and Draparnaud has discovered it in all the insects of the orthoptera ruminans genus.

This arrangement of the organs of respiration in animals with trachææ, approximates them to vegetables, and multiplies the points of similarity; in both, these organs are arranged over the whole body of the individual; they all respire oxygen, according to the observations of Fontana, Priestley, and Ingen-

houz, and in distillation they give analogous products, &c.

In order to form an exact idea of the agency of air in respiration, we must particularly examine, 1*st*, The changes which this fluid undergoes in the lungs; 2*d*, The changes by which the animal is affected in the act of respiration.

I. *Of the Changes which the Air suffers in Respiration.*

The first effect of the lungs upon air is a diminution of bulk. Borelli perceived this; Jurin made a calculation that a man inhaled 40 (48.5 English) cubic inches of air on a moderate inspiration, and that by the largest inspirations he could respire 120 (145 English); but that, in all instances, there is an absorption of a part. Hales estimated this absorption at a sixty-eighth part of the whole.

Since the analysis of the air has been better understood, great attention has been paid to its effects in respiration. Morozzo caused birds to respire in definite quantities of atmospheric air: in 1787, Lavoisier having placed a Guinea

pig under a bell inverted over mercury, and containing 1728 (2097 English) inches of oxygen gas, found the bulk reduced to 1672¼ (2028 English) after an hour and a quarter. By analysis he discovered that 229½ (278 English) inches of carbonic acid were formed; the remainder was pure oxygen. *(Memoirs of the Societé de Medecine*, 1787).

Dr. Goodwin, of London, proved in 1789, that a quantity of air, containing 0.80 parts azotic gas, 0.18 oxygen, 0.02 carbonic acid, yielded, after respiration, 0.80 azotic gas, 0.05 oxygen, and 0.13 carbonic acid. It may be concluded from the experiments of the same author, that the diminution of oxygen gas, and the augmentation of carbonic acid, are constant and progressive in the same quantity of air which is repeatedly inhaled, but not that the changes produced by subsequent respirations correspond with those produced by the first.

The absorption of air in respiration is, therefore, a well established fact: and supposing, according to the experiments of Robert Menzies, that the mean term of the quantity of air inspired is 43.73 (53. English) cubic inches, that a man respires twenty times in a minute,

and that he absorbs at each respiration 0.024 of oxygen gas, it is evident that the atmospheric air in which we live, would soon be exhausted of its respirable element, if nature did not employ powerful means to reproduce the oxygen.

By causing the air, as it proceeds from the lungs, to pass through lime-water, we may easily convince ourselves that carbonic acid is formed in respiration. Lavoisier and Seguin have proved beyond all doubt, that water is formed there in a like manner.

II. *Of the Effects of the Air in Respiration.*

The most marked effect of air in respiration, is the constitution in the lungs of a source of animal heat.

Hales and Boerhaave had already observed, that the blood acquired heat in passing through the lungs. Later naturalists have estimated this heat at $\frac{1}{100}$. Crawford found, that in a dog the heat of the arterial blood was to that of the veinous blood as 111 is to 100, and in a sheep, as 123 is to 100.

Buffon and Broussonnet have decided that the heat, in every class of individuals, is in proportion to the bulk of the lungs. It had not escaped the observation of Aristotle, that cold-blooded animals have only one auricle and one ventricle ; but Lavoisier was the first who maintained that animal heat depends upon the fixation and absorption of oxygen by the lungs. (Memoir read at the Academy of Sciences in 1777). Crawfort adopted this opinion, and supported it by additional facts in 1779.

This doctrine is a natural consequence of the fixation of a portion of oxygen gas in the lungs.

It follows from these principles, 1*st*, That the heat will be considerable in proportion as the air is pure; 2*d*, That those animals must be the warmest whose lungs are of the greatest bulk. These consequences are in perfect harmony with the facts and observations of naturalists and writers on physiology.

The second effect which air in respiration appears to produce, is the communication of the colour of vermillion to the blood. Lower had remarked this phenomenon, and considered it as an immediate result of respiration.

Every one knows that, when the blood remains some time exposed to the air, its surface becomes covered with a coat of vivid red, while the interior continues of a dark hue. Cigna observed, that the whole mass preserves the same dark colour, if it be covered with a coat of oil. Becaria satisfied himself that the blood continues dark-coloured in vacuo, and that its surface assumes a red colour when the contact of the air is admitted. Hewson imparted the vermillion tint to the veinous blood, by injecting air into a space of a vein confined by two ligatures. Thouvenel has proved that, by exhausting the air which reposes on the surface of the blood, we cause it to lose a great portion of its colour. Dr. Goodwin having raised the sternum of several dogs while living, and laid bare the trunks of the pulmonary veins and arteries, inflated the lungs by means of bellows, and saw that the blood which returned from the lungs was of a vermillion colour, and that, when the use of the bellows was suspended a minute, it became dark-coloured, as well in the veins as in the arteries. We may observe in the membraneous lungs of the lizard and the frog, that the blood becomes redder in

passing the pulmonary vessels, but that it assumes a darker hue as soon as the motion of this organ is suspended. M. Fourcroy has added to the observation already known, that if the veinous blood has already been reddened by the contact of oxygen gas, the colour passes into the purple of wine lees by the longer continuance of the same gas. It further results from the experiments of Crawfort, 1*st*, That an animal placed in a cold medium, consumes more air in a given time, than when placed in a warm one; 2*d*, The colouring of the blood is more perceptible in a cold than in a warm medium.

The above facts already warrant these conclusions: 1*st*, That the colour of vermillion is produced in the blood by oxygen; 2*d*, That this colour is more intense in proportion as the air is more pure or more condensed.

It has been proved by direct experiments made by Priestley and by Goodwin, that this colouring of the blood can be effected through the web of membrane which encloses it. The former of these naturalists filled a bladder with blood, and exposed it to pure air; that part which was in contact with the surface of the

bladder, became red, while the interior part remained dark-coloured: the latter, by directing a current of oxygen gas against the jugular veins, where he had arrested the circulation by ligatures, saw the blood assume a deeper tint of vermillion.

It only remains at present to understand the nature of the combination formed by the air with the blood, in order to compleat our insight into the theory of this acquisition of colour. We have already seen, that the air in respiration carried forth with it the carbonic acid and the water which were produced in the lungs; we are therefore warranted to conclude, that, during respiration, an abstraction of hydrogen and of carbon takes place; and we may reasonably conjecture, that to the extrication of these two principles the blood owes its vermillion tint. A direct experiment of Hamilton comes in support of this opinion: this skilful observer forced hydrogen gas into the blood, which he had confined in the jugular vein by two ligatures, and saw that, after leaving it in contact during an hour, the blood remained liquid after the experiment, and almost as black as ink; that by intercepting the blood in the veins du-

ring an equal time, it coagulates, without becoming as black as when it is exposed to the contact of hydrogen.

Lavoisier, Seguin, and Crawfort have concluded from these experiments, that the change of colour which the blood undergoes in the lungs, proceeds from the combination of hydrogen with oxygen, from which results the formation of water.

The lungs, therefore, may be regarded as an excretory organ, by which nature disencumbers the blood of certain principles, which by an incessant reproduction would otherwise exist in excess; while, on the other hand, the urine carries off all the salts, and some acids.

SECTION II.

Of Azotic Gas.

Azotic gas is the second constituent principle of the atmosphere, of which it forms four-fifths. Although this proportion appears to promise extensive use and great influence in the phenomena of nature and art, yet its

agency is by no means either so powerful or so marked as that of oxygen. We cannot without difficulty withdraw it from the bosom of the atmosphere, nor can we well obtain it but by separating it successively from its admixtures, oxygen and carbonic acid, by which means it remains alone.

Nevertheless, the azotic gas enters into several known combinations, and it is by the decomposition of these that it may be obtained. Berthollet has informed us, that the nitric acid, when digested upon them at a moderate heat of 70 degrees, disengages from most animal substances the azote, which is one of their constituent principles. The white gelatinous parts yield but little, the albumen and the serum furnish more, and the fibre is the animal part which contains the most. The flesh of young animals furnish less than that of old; that of carnivorous is somewhat richer than that of fructiverous creatures; and the azote is more easy of separation from the flesh of fish than from that of quadrupeds.

If ammoniacal gas be made to pass under a bell glass inverted over mercury, and filled with oxygenized muriatic acid, a quick and bril-

liant flame is instantly produced; a white dense smoke soon after obscures all the vessel, much caloric is evolved, and at the end of some minutes the sides of the bell glass, although previously dry, became loaded with streaks of water. After the oxygenized muriatic acid is completely saturated, nothing remains but pure azotic gas, proceeding from the decomposition of the ammonia: the water and the small quantity of muriatic acid, furnished by the combination of the oxygen of the oxygenized muriatic acid with the hydrogen of the ammonia, are deposited on the surface of the mercury.

If instead of mixing the oxygenized muriatic acid and the ammonia in the state of gas, we cause the former to pass over the latter in a flask, and collect the disengaged gas in the hydro pneumatic apparatus, nothing will be found in the flask but a little muriatic acid diffused in pure water, and the gas which has entered beneath the bell is pure azote. M. Fourcroy, to whom we are indebted for this experiment, recommends that it be made in a vessel exposed to a strong light, and to a temperature which is somewhat warm. He adds,

that the operation must be stopped at the very instant the azotic gas ceases to pass over.

The azotic gas is in general without odour when it is extracted from the atmosphere; but that which is a product of animal substances has, even when well washed, a peculiar smell; it is analogous to that of fish in an incipient putrefaction. This odour seems to arise more especially from some carbon which the gas receives from the animal substances; it deposits this carbon by long continuance over water, and forms, in this case, a dark deposit on the sides of the containing vessel.

Azotic gas is adapted neither to respiration nor to combustion: it modifies, or entirely deprives the oxygen gas of these two eminent qualities, according to the proportion in which it is united to it.

It is lighter than atmospheric air; their relation is in the proportion of 985 to 1000. The weight of a cubic inch is 0.4468 grs. (0.4447 grs. English), and that of a cubic foot 1 oz. 2 drs. 48 grs. (775 grs. English.)

When the azote is once brought into the state of gas, it is very difficult to reduce it again

to the state of combination. It appears to require a very high temperature in order to lose its gaseous form. Mr. Cavendish asserts, that a mixture of seven parts oxygen gas and three parts azotic, were, by the electric spark, converted into nitric acid.

Its combination, however, appears to be formed with less difficulty at the moment in which it disengages itself from bodies of which it is a constituent principle; thus we every day observe the production of nitric acid and of ammonia, by the decomposition of animal and vegetable matters. This doctrine has received some elucidation in the first volume of my *Elements of Chemistry*, 4th edit. article *Nitrate of Potash*, p. 213, &c.

SECTION III.

Of Hydrogen Gas.

THAT which the old chemists called *inflammable gas*, has received the denomination of hydrogen gas, ever since it has been acknowledged as one of the constituent principles of water.

Hydrogen abounds in vegetables and in animals, and it is to this principle that we must especially attribute the property which they possess of burning with flame. In distillation they give out this gas in large quantity, but the hydrogen extracted in this manner is never pure; for, beside being mixed with carbonic acid and other substances, it has of itself the property of holding more or less carbon in solution.

The decomposition of water by means of the metals, furnishes the hydrogen gas in its greatest purity. Iron or zinc are usually employed for this purpose.

By causing water to pass, drop by drop, into iron tubes at a red heat, a compleat decomposition of it is effected: its oxygen attaches itself to the iron, which it oxidizes, and in the mean while, the hydrogen disengages itself in the form of gas, which may be collected in the hydro-pneumatic apparatus.

But water is decomposed most easily by employing it to dilute sulphuric acid, and subjecting iron or zinc to the action of the acid in its weakened state: in this case, the water decomposes itself upon the metal which it oxidizes, and

the hydrogen is liberated in a gaseous form. This is the process which is used in our laboratories, to extract hydrogen gas when we wish to ascertain its properties.

This gas, which has the property of dissolving water, carbon, sulphur, and phosphorus, and of being impregnated with these substances in very various proportions, presents great modifications in its characters. Mr. Kirwan observed, that this gas possesses very little smell when prepared over mercury, but that it increases in volume and weight when transferred to the common pneumatic tub filled with water.

Like other combustible bodies, this gas does not burn except by the intervention and combination of oxygen. We may convince ourselves of this truth, by turning up a jar filled with hydrogen, and plunging into it a lighted taper; the taper is extinguished in the interior of the jar, and the gas is inflamed only at that part which is in contact with the atmospheric air. Hydrogen therefore burns in this manner like all other combustible substances.

The combustion of hydrogen gas proceeds tranquilly when it is pure; but if it be mixed

with a portion of atmospheric air, the combustion is rapid; it is effected at every point in an instant, and a detonation takes place, produced by the vacuum which is formed by the combination of the gases, and their reduction to water.

This gas is lighter than common air. The cubic foot of atmospheric air weighing 720 grs. (716.7 grs. English), one of hydrogen gas weighed 72 (71.5 English). M. Kirwan found the weight of hydrogen gas, compared with that of an equal volume of common air, in like temperature and pressure, to be as 1000 is to 84. The weight of this gas varies very much, owing to the difficulty which is experienced in obtaining it in great purity; that which is obtained by the action of diluted sulphuric acid upon iron or zinc in the hydro-pneumatic apparatus, is in general six or seven times lighter than atmospheric air. By employing mercury in the apparatus, it may be obtained twelve or fourteen times lighter than atmospheric air.

Bubbles of soap inflated by hydrogen gas, form small balloons, which rise in the air and may easily be inflamed: this is a curious experiment, but it may be rendered still more inte-

resting, by filling the bubbles with a mixture of the hydrogen and oxygen gases; in which case the inflammation takes place with explosion.

The lightness of this gas admits of its being transferred or poured, by placing the jar which contains it under another which is inverted: in this position the gas, being lighter than the atmospheric air, expels the air of the upper jar, and occupies its place.

This fundamental idea of the specific lightness of hydrogen gas, suggested to M. Charles the possibility of forming balloons by confining a considerable volume of gas in an envelope of taffety, rendered impermeable by a varnish of elastic gum, so that the weight of the volume of gas and its envelope was still less than that of an equal volume of atmospheric air.

The experiment of ascending made at Annonay, was the commencement of the career of the science of aerostation. MM. Montgolfier had, by heat, dilated a certain quantity of atmospheric air, so as to render it very much lighter than an equal volume of the surrounding air; but it was very soon perceived, that the difficulty of nourishing a continual source

of heat, the almost absolute impossibility of regulating at pleasure the degree of dilatation, and of preventing the surrounding stratum of air from heating and consequently diminishing the effect, rendered this apparatus very inferior to that formed by hydrogen gas.

The great use made, in the present age, of balloons, become the objects of public exhibition, has given rise to some very ingenious processes for extracting with ease and at small cost the hydrogen which may be wanted: some use cylinders of cast iron, which they fill with iron-turners' shavings, and heat to redness, in order to decompose water and extract its hydrogen; others employ the action of diluted sulphuric acid upon iron or zinc, and conduct the operation in tubs.

CHAPTER II.

Of the Mineral Part of our Planet.

MASSES of stone or of minerals constitute almost the whole of our globe; they present to us an immense variety in the nature of the bodies which compose them; but when, by analysis, we have reduced them to their elementary principles, and ascertained the properties of each, we easily succeed in dividing them into two classes, one of which comprehends those substances which are dry, insipid, inodorous, and of a specific gravity which does not exceed 4,5, while the other is composed of bodies perfectly opaque, of great specific gravity, and of a characteristic brilliancy: the earths compose the first of these classes, and the metals form the second.

Analysis has indeed already succeeded in characterising nine earths and twenty-three metals; but nature appears to offer us but a very small number of those bodies which are destined to very important offices in our ope-

rations. The other substances, concealed as constituent parts of some combinations little understood, or in which they existed in very small quantity, for a long time eluded our researches: the discovery of them does honour to chemistry, because it proves the perfection of its means of analysis; but in order to speak of the greater part of them, we must wait till their existence elucidate the phenomena of nature, or their properties, being better understood, add to the resources of our industry or of our wants.

The masses of stone appear to constitute almost the whole of our globe; the metals are to be found only at certain spots of the surface, or at moderate depths.

The earthy principles seldom exist there in a detached state; they are found mixed together, or dissolved by acids, and forming with them salts, which occur only at the surface of the globe, because the acids cannot be formed without the intervention of oxygen gas, which the atmosphere or the decomposition of water alone can furnish.

The metallic substances are seldom found free of all combination; oxygen, sulphur, or

phosphorus, are almost every where united to them; and the nature of these substances leads us to suppose, that the formation of metallic strata was subsequent to that of the earths, without, however, enabling us to infer either the epoch or the mode of their formation.

We are not, in our opinion, justified in separating the fixed alkalies from the earthy substances. M. Fourcroy and other chemists have already classed several earths along with the alkalies, of which they possess all the properties. The great solubility which, till within a late period, appeared to distinguish the alkalies from the earths, is possessed in common with them, by barytes and strontian; chalk, although little soluble, has nevertheless many properties which approximate it to the alkalies. Analysis demonstrates every day the existence of alkalies in earths and stones, of which they form an essential constituent part; we think, therefore, we are not authorised to separate in future the earths from the alkalies.

SECTION I.

Of the Earths and Alkalies.

We have already mentioned the distinctive character of the earths; it remains for us to give an abridged description of the properties they individually possess.

I. *Of Silex.*

Silex has been successively known by the denominations *vitrifiable* earth, *quartz*, *silicious* earth.

This earth exists nearly pure in rock-crystal. Bergmann's analysis of it shewed in 100 parts, 93 silex, 6 alumine, and 1 calcareous earth.

In order to obtain silex in a state of purity, let one part of rock-crystal be fused with four parts of potass, dissolve them in water, cause a precipitation by adding an acid in excess, and detach the alumine and calcareous earth by sul-

phuric acid. The insoluble residue, when carefully washed, yields only pure silex.

Silex is peculiarly harsh to the touch. Its particles diluted in water, are precipitated with extreme facility, and without exerting any adhesive attraction amongst themselves.

Its specific gravity is 2.65.

Bergmann had declared that water had the power of dissolving silex: Mr. Kirwan supposed that 10,000 parts of water could hold one part in solution at the temperature of the atmosphere. The first of these two celebrated chemists, who had analysed the incrustations which are formed by the waters of the famous Geyser in Iceland, acknowledged that they were of a silicious nature, and concluded that the temperature of this water, which, according to the observations of Detroil and Solander, is higher than that of boiling water, might effect the solution of this earth. But Black has demonstrated, that a quantity of caustic soda exists in these waters, and thus explained the presence of silex in the water of these springs.

Mr. Mackie, of the Royal Society of London, has proved that the whitish matter found between the knots of the bamboo, is silicious.

The fluoric acid dissolves silex, and evaporates it in form of white vapours, and deposits it on the surface of the water in which the acid is received.

The alkalies dissolve it very easily in the dry way. When they are used in a proportion exceeding an equal weight, the solution is more easy; but the combination assumes only an apparent solidity; it attracts the moisture of the air, and deliquesces into a liquid which is soluble in water.

When silex and an alkali are employed in equal parts, there results a fluid mass extremely pliant, ductile very susceptible of the operation of blowing, and of receiving every kind of form, whilst it is hot; it becomes hard and brittle on cooling, but preserves the forms which may have been given to it; its transparence is more or less perfect according to the purity of the materials employed: this is what is usually called *glass*.

M. Saussure succeeded in fusing a fragment of rock-crystal by the blow-pipe; the fragment was fixed upon a wire of *sappare*, which was less than the two hundredth part of a line thick, its length being about twelve times greater: the

substance fused at the point, ran towards the the base, and covered it with a coating of glass: the glass was transparent, colourless, and free from bubbles; it had no effect upon the *sappare*.

Ehrmann asserts, that he has melted the rock-crystal in globules, with a remarkable extrication of bubbles.

Lavoisier and M. Guyton were not able to fuse it by a current of oxygen gas, nor could Macquer in the focus of a burning lens.

This difference in the results, arises from the variety which exists in the composition of rock-crystals The silex which forms the base, and constitutes indeed almost the whole, is of itself infusible; but its fusion may be effected by an admixture of other earths, and this admixture often presents itself in the composition of rock crystal.

Silex forms the base of all hard quartzous rocks which give sparks with steel; and in nature is especially mixed with alumine, calcareous earth, and magnesia.

Almost all its combinations possess great hardness: the constituent parts are often cemented by iron, and in this case the mass is

coloured, and is in general of more difficult fracture.

It is silex which communicates to all compositions where it prevails, the property of producing sparks with steel.

II. *Of Alumine.*

All the earths which are called *clay*, *argil*, or *marl*, contain more or less alumine; but in no part is it found in a state of absolute purity.

The means most generally employed to obtain this earth in purity, consist in precipitating it by ammonia, from a solution of alum, and in washing the precipitate in boiling water, in order to separate any part of the undecomposed sulphate which may remain in it. The residue is afterwards heated, in order to expel any small portion of ammonia which might still remain.

Alumine absorbs water with avidity, and is dissolved in it easily: when it is impregnated with this liquid, it assumes a semi transparence, which gives it the appearance of a jelly. If, in this state, it be exposed to the air to pro-

duce a desiccation, its particles recede, and contract themselves into square divisions.

Alumine, when dry, adheres strongly to the tongue.

Its specific gravity is 2,2 to 2,3.

Alumine, when a strong heat is applied to it, contracts such a degree of hardness, as to produce sparks with steel. In this state it is no longer capable of being dissolved in water; and it is this property which renders it peculiarly adapted to form the base of the manufactures of porcelain.

Its attraction for water is very strong, and when it has not undergone a calcination, enters into a kind of combination with it: when submitted to desiccation, it retains this liquid with great force, nor does it abandon it but by very slow degrees; so that at a very high temperature it still preserves a portion, and suffers contraction till it be completely dissipated. In proportion as this liquid evaporates, the cohesion increases, the pores contract, the hardness augments to such a degree that the alumine gives sparks with steel, and is no longer susceptible of solution nor yet of dilution in water. It is, in this state, a new substance, which pos-

sesses properties altogether peculiar; nor does it resume its primitive qualities till it has been dissolved in the acids or the alkalies, in order to precipitate it from these new combinations, and to reduce it to its original state.

According to the experiments of Macquer and of Lavoisier, alumine gave no symptom of melting in the focus of the burning lens; but when tried by the blow-pipe with a stream of oxygen gas, it fused into a white semi-transparent enamel, and assumed a degree of hardness sufficient to cut glass; a fact which has been observed by Lavoisier, Guyton, and Ehrmann.

The mixture of chalk facilitates its fusion in a singular degree. It is this mixture which renders gravel, marls, and the greater number of clays, so fusible, that they melt at the very moderate heat of the furnaces of our potteries.

The borate of soda, and the phosphates contained in urine, dissolve it, according to M. Mongez, Kirwan, &c.

Alumine is easily dissolved by the fixed alkalies when caustic. When it is precipitated from its solution in the acids by means of the alkalies, it is again dissolved if these be added in excess.

This earth, when in a state of purity, is white; and this quality renders it a most valuable medium in the use of the colouring matters.

It unites readily with oily substances, and forms with them combinations which easily attach themselves to different stuffs, and thereby serve the purpose of mordants to the colours, as is the case in the Turkey red; or which become diluted and are carried off by water, as in the methods of cleansing grease from cloaths, and in the process of fulling.

Alumine, which is so generally united with silex in the stoney compounds which form the principal mass of our globe, concurs in imparting to it that smoothness and polish of surface which silex could not of itself assume.

These two primitive earths mixed by art in suitable proportions, constitute our different kinds of pottery. An union of their useful qualities corrects their respective defects, as we shall remark more particularly when we come to speak of potteries.

III. *Of Zircon.*

Klaproth has proved that the hyacinth of Ceylon contains a peculiar earth in intimate union with silex : this learned chemist had before found this earth in the jargon of Ceylon, and had given it the name of *zirconian* earth. Chemists have at present adopted the appellation *zircon.*

Guyton afterwards found the same principles in the hyacinth of Expailly and in those of Ceylon ; and M. Vauquelin has given us still more particular information respecting the properties of this earth.

M. Vauquelin extracted the zircon by the following process : he exposed to heat, during two hours, in a silver crucible, 100 parts of pulverised hyacinth with 600 parts of caustic potash ; he diluted the green-coloured mass in 10 or 12 parts of water ; he next added muriatic acid in excess, and effected a solution by the aid of a gentle heat. As soon as the solution was effected, he evaporated to dryness by a moderate heat, taking the precaution of continually agitating the matter towards the end of

the operation, to facilitate the evaporation of the acid which holds the zircon in solution. Afterwards he poured upon the residue of this evaporation, a quantity of water sufficient to dissolve the undecomposed saline parts. It is proper to add a few drops of muriatic acid, in order to dissolve any small portion of zircon which the acid may have deposited towards the end of the evaporation; for the muriate of zircon is very easily decomposed.

By these means the silex is separated; this earth is then washed till the water yields no precipitate with the solution of nitrate of silver.

Silex forms 0.33 of the hyacinth. It is white, its crystals are transparent laminæ, it fuses with borax without effervescence, and produces a transparent colourless glass.

In order to ascertain that no small residue of silex remains in the muriatic acid, the muriate of zircon should be subjected to several repetitions of alternate solution in water and evaporation in a gentle heat.

When the muriate of zircon deposits no longer any silex, it is next dissolved in a large quantity of water, and a precipitation is caused by an alkali; the precipitate is washed, and

exposed to a red heat in a silver crucible. By this method, M. Vauquelin obtained 65,5 of pure zircon in 100 parts of hyacinth.

The hyacinth contains further a small portion of iron. That of Ceylon yielded,

Silex	-	0.32	98, loss 0.2, = 100.
Zircon	-	0.64	
Oxide of iron,		0.02	

That of Expailly yielded,

Silex	-	0.31	0.98, loss 0.2, = 100.
Zircon	-	0.65.5	
Iron	-	0.01.5	

In order to procure zircon on a large scale and at small cost, M. Vauquelin proposes to substitute common crucibles for those of silver, and to employ 8 or 9 parts of the potash of commerce, which should be mixed with well pulverized hyacinth: this mixture should be thrown, by spoonfuls at a time, into a crucible heated to redness; no more mixture should be added till the first be melted. When the whole is in fusion, a violent heat is applied and supported during an hour and a half. The heat should be applied a shorter or greater length

of time, according to the quantity of materials on which we operate.

After the crucible is cold, it is broken, the mass is reduced to powder, and then made to boil with water in a leaden vessel; the insoluble part is suffered to subside, the clear liquor is poured off, and the earth is then washed till the washings cease to produce any precipitation with muriate of barytes.

This washing is necessary to detach all the sulphate of potash which may exist in the potash of commerce, and which would decompose the muriate of zircon.

After the earthy mass has been well washed, it is next diluted in 20 parts of water, and pure muriatic acid is poured upon it in excess; the whole is boiled during a quarter of an hour in a vessel of lead.

The solution is filtered, then evaporated, and any silex which may be precipitated, is separated; the solution and filtration are repeated, and the zircon is precipitated by pure carbonate of soda; the whole is washed and dried, and we obtain the carbonate of zircon. An excess of the carbonate of soda must be avoided, lest it should retain the zircon in solution.

This earth, when calcined, has a white colour, and its specific gravity is considerable.

Like silex, it is harsh to the touch.

It is insoluble in water.

It is tasteless.

Without addition, it is not fusible by the blow-pipe; with borax, it produces a transparent colourless glass. The microcosmic salts have no effect upon it.

It retains, when dried in the air, water sufficient to remain transparent, and has the appearance of gum-arabic; it is therefore yellow, and has a vitreous fracture; this quantity of water augments its weight about one quarter.

Zircon melts when heated strongly in the fire of a forge and in contact with charcoal, and assumes such a degree of hardness, that it scratches glass and strikes fire with steel, and has a specific gravity of 0.435.

Zircon unites with the acids and forms salts, of which some are soluble, others insoluble: the former are the nitrate, muriate, acetate, benzoate, and malate; the latter are the sulphate, sulphite, phosphate, phosphite, fluate, borate, carbonate, oxalate, citrate, tartrite, gallate, &c.

The zircon is not easily soluble, and does not readily combine except it be moist, at the moment after it has been precipitated: when it has been desiccated, it submits with difficulty to these combinations.

It is but weakly attached to the acids; even a moderate heat dissolves these combinations. The salts of zircon have a taste in a very considerable degree astringent, and which much resembles that of certain metallic salts.

Respecting the affinities of zircon to the acids, they are in order as follows: sulphuric, muriatic, and the nitric acids. Almost all the vegetable acids have a stronger affinity to this earth than the mineral acids. The oxalic, tartaric, citric, gallic, and sacco-lactic, produce very copious precipitation in the solutions of the sulphate, muriate, and nitrate of zircon.

It appears that all the alkalies and all the earths have a stronger affinity to the acids than zircon has.

Zircon forms with the ammoniacal salts, triple salts soluble in water.

It is precipitated from its solutions by the carbonated alkalies, and is redissolved by an excess of these menstrua.

It may also be precipitated from its solution by the prussiates, the hydro-sulphurets, and the gallic acid; a circumstance which approximates it to the metallic oxides.

IV. *Of Glucine.*

It is M. Vauquelin to whom we are indebted for the discovery of glucine; it was supplied in the analysis of the aqua marine, or beryl.

100 parts of beryl reduced to powder, were fused in 100 parts of caustic potash; when cold, water was added to the mass, and afterwards muriatic acid: in which manner a complete solution was effected.

This solution in muriatic acid was evaporated to dryness; towards the end of the evaporation, the liquor thickened into a jelly: the matter was dried, and then diluted in water; a part was dissolved, but there remained a white granulous transparent powder; this substance amounted to 69 parts of the whole, and possessed all the properties of silex.

Carbonate of potash was next poured into the solution; the precipitate collected and drained,

was digested with caustic potash: the greater part of the matter was taken up. There remained an insoluble residue, which was washed and dried to redness; it had a greyish brown colour, and formed nine parts of the whole. It is in these nine parts that the glucine is found.

The alkaline solution was super-saturated with muriatic acid, and a precipitation effected by carbonate of potash; the sediment, when washed and dried, weighed 21 parts. This substance appeared to be pure alumine.

The nine parts, insoluble in the potash, were next dissolved in nitric acid; the solution was evaporated to dryness, and the residue dissolved in water. The solution assumed a reddish yellow colour, indicating the presence of iron: a solution of the hydro sulphuret of potass precipitated the iron of a black colour; the liquid above the precipitate then became clear and colourless; it was evaporated to dryness, and towards the end resumed a red colour. This residue, left during twenty-four hours in a capsule, was reduced to a thickish liquor, of a yellowish red colour; water added to it, dissolved the whole mass; the solution was red-

dish and varying; placed upon a warm sand-bath, red flakes were quickly formed, and the liquor became as clear as water. These flakes also were oxide of iron.

To the solution thus purified of all iron, the common carbonate of potash was added, and 12 parts were obtained of an earth white and soft to the touch, and which dissolved with effervescence in the acids. This earth, on separating from the nitric acid, absorbed $4\frac{1}{2}$ parts of carbonic acid; the 9 parts, therefore, which had been subjected to the operation, had deposited $1\frac{1}{2}$ part of oxide of iron, which leaves 7.5 for the pure earth.

M. Vauquelin, by calculating the small quantity of glucine which is attached and retained by the alumine precipitated from the beryl, and also that dissolved by the potash, found that beryl contains 16 parts in 100.

M. Vauquelin has demonstrated the existence of this earth in the emerald of Peru, in which neither he nor M. Klaproth had before discovered it; but M. Haüy having observed to him, that the characters of specific gravity, form, and hardness, were absolutely the same in the two substances, this natural similarity

induced him to try another analysis, and he then discovered this new earth; which circumstance proves, that constituent principles may be conjectured by characteristics which are merely external.

The specific characters of glucine are:

1. To form salts which are saccharine and astringent.
2. To be very soluble in sulphuric acid.
3. To precipitate alumine.
4. To be itself completely precipitated by ammonia.
5. To have affinities to the acids which occupy the intermediate space between the affinities of magnesia and alumine.

The following are its general properties:

1. It is white.
2. It is tasteless.
3. It is insoluble.
4. It adheres to the tongue.
5. It is infusible.
6. It is soluble in the fixed alkalies; and,
7. Insoluble in ammonia.
8. It is soluble in carbonate of ammonia; and,
9. Soluble in all the acids, excepting the carbonic and phosphoric.

10. It is fusible with borax, and forms with it a transparent glass.

11. It absorbs one quarter of its weight of carbonic acid.

12. It decomposes the salts of alumine.

13. It is not precipitated by well saturated hydro-sulphurets.

V. *Of Ittria, or Gadolinite.*

Gadolin discovered this earth in 1794, and gave it the name of *Ittria*.

M. Ekeberg afterwards analysed the earth of Ytterby in Sweden, where Gadolin had found his new earth, and he gave it the name of *Gadolinite*.

M. Vauquelin has subjected the same earth to experiment, and made us acquainted with its principal qualities.

It is white, without smell and taste; it is insoluble; it resists the action of the caustic alkalies, but is dissolved by the carbonate of ammonia; its combination with sulphuric acid is accompanied with emission of heat, and a salt is suddenly precipitated in grains, shining, and sparingly soluble in water.

The prussiate of potass and the oxalic acid precipitate it from its solution in the acids.

The oxalates of ittria are insoluble and very heavy; they differ in this from the oxalates of glucine, which has, in other respects, some analogy with ittria; which, however, differs not only in this property, but also in the precipitation of ittria caused by prussiate of potash, which latter does not decompose the salts of glucine.

According to the analysis of M. Vauquelin, ittria forms 0.35 of the earth of Ytterby: the remainder consists of silex, calcareous earth, oxide of iron, and manganese. Ekeberg had found it in the proportion of 0.47, and Klaproth in that of 59.75.

VI. *Of Magnesia.*

Like all the other earths, magnesia is no where found in a state of purity. The earth which hitherto appears to present it in a state the nearest approaching to purity, is that of Salinelles, near to Sommieres, in the department of Gard, where M. Berard has shewn

that it is mixed with silex in the proportion of 22 parts pure magnesia, 45 silex, 1 oxide of iron, and 32 water.

It exists also, mixed with silex and with alumine, in talcs, in the serpentine earths, in asbestos, and generally in all the unctuous stones which admit of being worked in the lathe.

Nature presents it to us also in the state of a salt, almost always combined with the sulphuric acid.

This combination is formed by the efflorescence or decomposition of certain secondary schists more or less charged with sulphur: in proportion as the sulphuric acid is produced by the slow combustion of the sulphur, it attaches itself to the component parts of the schist, and gives rise to the sulphate of lime, magnesia, alumine, or iron. I have seen in the mountains of Aveyron, decompositions of this kind, in which the sulphate of magnesia was so abundant, that it predominated over all the others, and rendered the elaboration of this mineral in order to extract its salt, very advantageous. M. Tingray has made the same observation respecting some mountains in the neighbourhood of Geneva.

It is by the decomposition of the sulphate of magnesia that this earth is usually obtained: for this purpose a carbonate of potash is used, and the precipitate is calcined, in order to disengage the carbonic acid. It forms ternary combinations when precipitated by ammonia.

Magnesia, when pure, is very white, light, and spongy.

In order to give it the whiteness which is observable in that which some apothecaries employ in the uses of medicine, it must be prepared with very pure potash, washed with care in copious quantities of water, and be dried between paper.

Its specific gravity is about 2.33.

It turns green in a feeble degree, the syrup of violets and the flowers of the mallow.

It unites with almost all the acids, and forms with them salts, which are for the most part bitter, and very soluble.

It is insoluble in water, but forms with it a slightly cohesive paste.

According to the experiments of Lavoisier and M. Guyton, magnesia cannot be fused even by a stream of oxygen gas; but with the borate of soda, or the phosphate of urine, it

fuses before the blow-pipe with effervescence. It impedes the fusion of all mixtures of earths, where it is present in a considerable proportion.

VII. *Of Lime.*

The case is the same with lime as with most other earthy substances; it is in nature rarely found in a state of purity.

The only observations I know respecting the existence of native lime, are the following: Falconer asserts that he has found it pure near Bath; Wallerius asserts that, on the coast of Maroc, native lime has been drawn from the bottom of the sea along with soda; Monnet assures us, that it has been projected by the eruptions of the volcanoes in the upper Auvergne; Laumont speaks of a spring at Savonnieres, near Tours, which contains pure lime.

After the testimony given by these authors, we cannot refuse to admit the existence of native lime; but it is evident that, in all these cases, its formation is owing to subterraneous fires, which have calcined the calcareous stone. The facility which lime possesses of passing in-

to the state of a carbonate, prevents its remaining any length of time in the form of lime: it can only be preserved in this state so long as it is carefully guarded from the contact of the air, and therefore either enveloped in strata of earth, or immersed under water.

When it is our object to procure pure calcareous earth, crystals of the carbonate of lime should be employed, and after a careful washing, be dissolved in distilled acetic acid; a precipitation should then be operated by the carbonate of ammonia, and the precipitation be washed and then calcined.

As lime is of very extensive use in the arts, constituting the base of almost all our cements, it is extracted on a large scale from the carbonates of lime which contain it; and on this account they are called *lime-stones,* or *calcareous stones.*

But we must not employ indiscriminately all sorts of lime-stone; the very various mixture of lime with other earths, the porous texture, the weight and the colour of lime-stones, constitute numerous differences, which the burner of lime ought to understand in order to regulate his choice of the material. Preference is usu-

ally given to a calcareous stone which is of a bluish-grey colour, sonorous and hard, breaking in sharp angles, and preserving, after calcination, its form, and almost its primitive hardness. Bergmann observes, that almost all stones which become brown during calcination, contain a portion of manganese, and that the lime formed from them is of an excellent quality. Dr. Higgins is of opinion that the best lime is obtained from the hardest and most compact stone, broken into small pieces, and heated gradually till the stone ceases to produce effervescence.

The presence of magnesia and of alumine is injurious to the good quality of the lime, in as much as calcined magnesia will not unite into a body with water and sand, and the alumine, which hardens by calcination, will not separate again so as to form a requisite paste.

Silex, which has the property of hardening with lime when its mixture with it is aided by water, may naturally be found in the proportions requisite to form the materials of very good cement: the stones collected on the shores of La Manche, and in some parts of the Ce-

vennes, present to us the due proportions of this natural cement.

When our choice is fixed of a good quality of stone, the art of burning or calcining offers two methods only which are practised: the nature of the combustible which we have at our command, must determine our adoption of the one or the other.

1. When the calcination of the stone is to be effected by wood, we must build of brick or stone, a portion of a cylinder or tower open at top, of the height of 10 or 12 feet, and 6 or 8 broad: an opening is formed at some point of the circumference of the base, in order to introduce the combustible and give access to the air. In the interior, and to the full extent of the circumference of the tower, an arch should next be built, in forming which the largest pieces of the lime stone should be employed; this arch is filled with all the material which is intended for calcination, and the fire is kindled underneath: the flame passes through the fissures left between the fragments of stone, it envelopes the whole in a nearly equal degree, and the fire is supported till the stone is observed to be of a fine red colour, penetrated

with the fire like a coal, and till the flame is become very white.

2. When the calcination is performed by turf or coal, a furnace or kiln is used of the shape of an inverted cone, at the point of which a lateral opening is formed, to admit the access of the air and to take out the lime. The kiln is charged with alternate strata of turf and stone: the inferior layer is kindled, which calcines that of stone resting upon it; so that as the layer of combustible is consumed, the calcined stone falls to the door, and is taken away.

The mass within the kiln, therefore, gradually sinks, and care is taken to add fresh layers of stones and of turf, in order that the kiln may remain full, or charged: in this manner may the furnace continue to be supplied, without interruption of the process, as long as may be desired.

In order that the lime may be of good quality, it is not only necessary that a good choice be made of the stone employed, it is further requisite that the stones be of a moderate size, and that, taken one with the other, they be of a nearly equal bulk; otherwise the calcination cannot be equal at all points, and the lime-

stone may be burnt at the surface, while the interior escapes unchanged; which often happens: thus, nothing is more common than to see drawn from the pits in which lime is slaked, pieces of stone, of which the surface only has separated in the water. It is also necessary that the burning be carefully managed; for if the heat be continued too long, and especially if it be too strong, a degree of calcination is produced which will afterwards prevent the lime from slaking: this is what is called *caked* lime. If, on the contrary, the heat be not sufficiently strong to disperse the carbonic acid, it preserves, when broken, its original consistence, and is therefore equally incapable of slaking.

Beside this suitable degree of fire, it is further necessary to apply the heat equally to all parts of the kiln, in order that the burning may extend equally through the whole, and may terminate at the same time.

Whatever precautions may be used, as the heat will still necessarily be more vivid near the vault when wood is employed, care should always be taken to place in this part the largest stones, and the smaller fragments are placed at the top.

That lime is esteemed the best, which slakes most readily in water, and in slaking gives out the greatest heat; which moulders into the finest dust; which dissolves in vinegar without effervescence, and without leaving any residue.

The properties which distinguish lime from all other earths, are the following:

Lime has a sharp and caustic taste.

Its specific gravity is 2.3, according to Kirwan, and 2.720, according to Bergmann.

It imbibes water with avidity and hissing. gives out heat and smoke, bursts, falls into powder, and augments considerably in volume.

Six hundred and twenty-four parts of water dissolve one of lime, at the temperature of 60 degrees of Fahrenheit. According to Mr. Kirwan, this solution is called *lime-water*. The mere contact of the air precipitates it in a short time, in the form of an insoluble carbonate.

The acids dissolve it without effervescence, but with disengagement of heat.

According to Lavoisier, it is infusible by the heat of oxygen gas; but M. Guyton assures us, he has reduced it, on a spoon of platina, into a white opaque enamel.

It facilitates, by its mixture, the fusion of all other earths.

VII. *Of Barytes.*

Barytes is found in nature combined with the sulphuric or the carbonic acid: it forms, in this state, extremely heavy stones, which generally consist of laminæ applied one upon the other, and very brittle.

Scheele and Bergmann at first proposed to calcine to redness in a crucible, a mixture of seven parts of sulphate of barytes with one part of charcoal: the residue is thrown into water, and after filtration, muriatic acid is added to the liquor. A considerable precipitate is thrown down, and then separated by filtering the liquor; the water which passes through the filtre holds the muriate of barytes in solution, from which the earth is precipitated by the carbonate of potash; a simple calcination is then sufficient to disperse the carbonic acid of the precipitate.

Hahnemann and Knoch have proved, that, by this method, the barytes was never obtained pure; but I have convinced myself, that all the deficiency of this process may be obviated, by supporting the calcination at a red heat during

two or three hours: water will then dissolve almost the whole of the residue, which is in the state of carbonate, and which, upon cooling, falls into crystals, foliated like those of the boracic acid.

Wiegleb advises to expose the ponderous spar (sulphate of barytes) to a red heat along with an alkali: his process, corrected by Westrumb, consists in taking one part of pure ponderous spar and two parts at least of pure potash: this mixture, after being triturated, is put into a crucible, and heated to redness during three or four hours; it is suffered to cool, and water is then boiled upon the residue, to separate all that is soluble, and the insoluble part, after being dried, is dissolved in muriatic acid; the solution is passed through the filtre, and evaporated to dryness by a slow heat. It is again dissolved in water, filtered and evaporated, till a pellicle is formed, and the salt is obtained white as snow. The barytes is then precipitated from this muriate by means of an alkali.

As barytes has a stronger affinity than the other earths to the muriatic acid, advantage may be taken of this property, in order to se-

parate those which may be dissolved in the acid at the same time with the barytes.

M. Vauquelin has published a process, by which the pure barytes is with economy extracted from the nitrate of that earth. It is sufficient to subject the nitrate to the action of fire in a porcelain retort: this salt melts, swells in bubbles, and gives out much oxygen and azotic gas; it emits very little nitrous vapour. When no elastic fluid is any longer disengaged, the retort is found to contain a mass which is grey, solid, and of a sharp caustic taste: this is pure barytes.

The specific gravity of this earth exceeds 4.0, according to Mr. Kirwan; and to this extraordinary weight it owes the name of barytes.

Barytes, exposed by Lavoisier to a flame fed by a stream of oxygen gas, melted in a few seconds; it expanded, and spread itself upon the charcoal; after which it began to burn, and continued till the whole disappeared. This combustibility it possesses in common with metallic substances, which it also approaches with respect to its specific gravity, the vein which it forms in the mountains in which

metals are found, which it very often accompanies, and the readiness with which its colours change when it is exposed to the light.

MM. Fourcroy and Vauquelin have observed it fuse before the blow-pipe, boil, and form into globules, which penetrate the charcoal.

It effloresces in the air, separates, breaks with force, swells in bubbles, emits heat, and becomes white. It slakes rapidly in water; it absorbs 0.22 of its weight of this liquid and of carbonic acid. It attracts water with such avidity, that it melts in it with noise, emits considerable heat, and hardens with it to such a degree, as to form a kind of cement, very tenacious and adhering strongly to glass. A small additional quantity of water changes it into a white powder, with increase of bulk; and if water sufficient to cover it be added, it is dissolved with a hissing noise, and afterwards crystallizes in transparent needles, which form into groupes.

Cold water dissolves a twenty-fifth part of its weight; boiling water takes up more than a half, and deposits, on cooling, very beautiful

transparent prisms, which effloresce and become pulverulent in the air.

Barytes is precipitated from its solution more readily than even lime, by the carbonic acid.

The solution of barytes decomposes the solution of soap, and the nitrates of mercury, lead, and silver.

It reddens strongly the blue of the mallow, violet, &c.

The oxalic, citric, phosphoric, and phosphorous acids, precipitate barytes from its solutions; but the precipitate is again dissolved if these acids be added to the liquor in excess.

Barytes, when pure, is soluble in alcohol.

It acts upon sulphur the same as the alkalies, potash, and soda.

Its great solubility in water, and its property of readily crystallizing, distinguish it from all other earthy principles.

Barytes and its compounds are poisons to the animal economy. MM. Huzard and Biron gave to some horses the muriate and carbonate of barytes, in doses of 118 grains (English) every day, and these animals died suddenly after having taken them for a few days. A dog which M. Pelletier caused to swallow

25 grains (20.5 grs. English), was seized with vomiting, and died within eight hours afterwards.

It is this poisonous quality which has procured to the carbonate of barytes of Anglesark, in Lancashire, the name of *rats'-stone.*

Crawford obtained some successful results by the use of muriate of barytes in scrophulous maladies.

IX. *Of Strontites.*

Strontites is a primitive earth, known only since the 4th November, 1793. It is to Dr. Hope, Professor of Chemistry in Edinburgh, that we are indebted for the first knowledge of this earth. This chemist first called it *stronite;* and after him, MM. Klaproth, Blumenbach, and Sulzer, designated it by the name of *strontianite.* Pelletier, who has left some excellent experiments on this earth, gave it the name of *strontiane,* because it was found, in the first instance, at Strontian in Argyleshire, in the north-west of Scotland, where it accompanies a vein of lead ore. It is nevertheless to be ob-

served, that the different names which we have mentioned, have been given to the stone, which is a carbonate, and that we here apply it to the pure earth, free of every combination.*

The carbonate of strontites has also been found at Leadhills, in Scotland.

M. Vauquelin has proved the existence of sulphate of strontites in the quarries of Montmartre.

M Lelièvre has found it in the clay-pits of Bouvron, near Toul, in the department of the Meurthe.

MM. Guyton and Pelletier have demonstrated its presence in the ponderous spars.

In order to obtain strontites perfectly pure, Pelletier advises to mix 10 parts of charcoal with 100 parts of carbonate of strontites; it is formed into a ball by the means of a paste made of starch, and the ball is put into a crucible, which is luted and covered with charcoal. The crucible thus covered, is exposed to the action

* This paragraph refers only to the names given to this earth by foreign chemists: it is almost superfluous to add, that English chemists have adopted the appellation of *strontites*. T.

of a strong fire during at least an hour. After this operation, the carbonic acid is found to be dispersed, and the residue amounts to only 72 of its original weight. This residue dissolves in boiling water, and the solution, when filtered and left to cool, deposits crystals of pure strontites. The sulphate of strontites may be treated in the same manner; the sulphur which remains mixed with the strontites, is separated by repeated washing in hot water. The strontites is always deposited by crystallization.

The carbonate and sulphate of strontites are soluble in the nitric acid, which displaces the carbonic. The nitrate deposits octaedral crystals: it may be decomposed by heat, and pure strontian be thus obtained.

The combinations of strontites give to the taper a beautiful purple flame, which characterizes and indicates the presence of this earth wherever it may be combined. It is particularly the solution of these salts in alcohol which produces this effect, and distinguishes the salts of strontites from those of barytes, the flame of which is of a bluish white colour.

Strontites is six times less soluble in water

than barytes; it is not fusible by the blow-pipe, but it shines with phosphoric flame. It is at the same time less sharp to the taste than barytes.

Pure strontites, when exposed to the air, swells, emits heat, effloresces, and attracts carbonic acid. Its solution exposed to the air, becomes covered with a pellicle of the carbonate, like those of barytes and lime.

X. *Of Potash.*

Potash, soda, and ammonia, have hitherto formed a class of substances which chemists called *alkalies*, and were known by the following characters:

1. A sharp, burning, and caustic taste.

2. The property of turning into green the blue colours of the violet, the iris, and the mallow; of reddening paper coloured yellow by a slight infusion of turmeric; of neutralizing the acids, and forming with them more or less soluble salts; of combining by fusion with silex, and of forming soaps with oils, &c.

But the greater part of the earths of which we have already spoken, possess these properties, and we cannot any longer refuse to asso-

ciate them with the alkalies: magnesia, lime, strontites, and barytes, are those in which the most alkaline qualities are united, and especially the three last.

Potash, which has been somewhat inaptly denominated *vegetable alkali*, is found in the ashes of all vegetables, and analysis has demonstrated its existence in several stones. M Klaproth has discovered potash in the pumice-stone of Lipari: the pearlstone of Hungary also contains it. M. Vauquelin extracted $\frac{18}{100}$ from the lepidolith of Rohena in Moravia, and $\frac{16}{100}$ from the green feld-spar of Siberia.

The lees of wood-ashes, when evaporated to dryness, yield a black coloured alkaline residue, called *potash*, which only requires to be calcined in order to become white, and be received in commerce under the name of *pearl ash*.

As this alkaline salt acts a very distinguished part in the arts, and forms one of the principal agents in our laboratories, we shall enter into a few details respecting the manufacturing of it.

All plants, with the exception of those which grow in soils impregnated with sea salt, furnish the potash, but all do not contain it in equal quantities.

And not only do vegetables, in equal weights, give different quantities of ashes, but the ashes produced from them yield also in unequal degrees, the potash.

The herbaceous plants are, of all vegetables, those which produce the most ashes: shrubs furnish more than trees, leaves more than branches, and the branches more than the trunk.

The husks and fibres of certain esculent plants, as the stalks of the French and the large bean, the melon, the cucumber, the cabbage, and artichoke, produce richly the potash.

The leaves and fibres of tobacco, which form the refuse in the manufacture of snuff; the stems of the sunflower, the maize, and the potatoe, offer further rich resources.

Fern, heaths, the fruit of the horse-chesnut, broom, and thistles, may be a great assistance in supplying a manufactory of potash.

The Directors-general of the saltpetre and gunpowder works in France, published in 1779, the result of a great number of experiments on the product in ashes and in alkali, which they had obtained from different vegetables, of which they had directed the combustion and carefully lixiviated the ashes.

M. Pertuis has prosecuted this kind of research, and imparted to us the result of his labours.

Mr. Kirwan has given a table of the product, in ashes and in alkali, which he obtained from 1000 lbs. of each of the vegetables he submitted to experiment; we shall subjoin this table, which will be useful to those who may wish to devote themselves to speculations of this nature.

Name of the Vegetable.	Product in Ashes.	Product in Alkali.
Stem of the Maize . .	88.00	17.05
Large Sunflower . . .	57.02	20.00
Twigs of the vine . .	34.00	5.05
Box	29.00	2.26
Sallow	28.00	2.85
Ash	23.05	3.09
Oak	13.05	1.05
Aspen	12.02	0.74
Beech	5.08	1.27
Fir	3.04	0.45
Fern in August . . .	36.46	4.25
Wormwood	97.44	73.00
Fumitory . : . . .	319.00	79.00

It results from the experiments made by the managers, 1. That the potashes produced by different vegetables have different colours; 2. that the quantity of alkali is not by any means

in proportion to the quantity of ashes in the vegetable; 3. and that ashes require very different proportions of water to become exhausted by lixiviation.

Name of the Vegetables.	Quantity of the Vegetable employed in Combustion.	Produce in Ashes.				Water employed in Lixiviation.	Produce in black or unburnt Ash.				Colour of the black or unburnt Ash.
	lb.	lb.	oz.	drs.	gr.	lb.	lb.	oz.	drs.	gr.	
Box	800	23	0	0	0	216	1	12	6	21	Bright lead ore.
Oak	915	12	0	5	0	124	1	6	4	12	Brownish-grey.
Beech	337	5	3	0	0	66	1	4	6	0	Coffee with milk.
Elm	981	11	0	1	0	216	1	3	5	36	Greyish-white.
Ash	1018	24	1	6	0	300	3	15	0	0	Reddish-Grey.
Aspen	648	8	1	5	0	120	0	7	6	0	Deep black.
Fir	730	2	7	7	0	80	3	7	0	0	Light black.
Sallow	800	22	12	5	36	200	2	5	1	18	Light brownish-grey.
Vine Twigs	800	27	0	4	36	276	4	10	4	0	Whitish-grey.
Turnsole	200	20	11	4	0	333	4	0	0	0	Milk white somewhat yellow.
Maize	440	39	0	0	0	612	7	12	1	56	Ash-coloured.

Some particular experiments which I caused to be made in the department of Vosges, by the Directing-manager of the manufactures of potash in this circle, at the time I was Director-general of the gunpowder and nitre works, gave the following results:

	lb.	oz.	
10 lb. ashes of broom yielded	2	5	potash.
10 lb. ditto of fern - - -	3	5	
10 lb. ditto of heath - - -	1	12	
10 lb. ditto of roots of pine -	2	9	
10 lb ditto of maize straw -	4	3	

When it is intended to manufacture potash from the plants of the field, it is necessary to cut and gather them with care, so that no earth may remain adhering to them, or communicate impurities to the alkali.

They should be collected together in heaps, at certain distances in order to be burnt at different points, and to save labour.

The plants should be suffered to dry before the combustion is commenced, otherwise it will be difficult, long, and imperfect.

When a great number of vegetables, sufficient to support the combustion for a considerable time, are collected and heaped toge-

ther, the combustion is effected with the following precautions:

A situation is chosen sheltered from the wind, at a distance from any dwelling, and the neighbourhood of which is clear of vegetables, so as to prevent all probability of communicating any conflagration.

The plants intended for combustion, are added by degrees to the fire: care is taken not to add beyond the proportion in which those on fire are converted into ashes; and the coaly matter of the fire is moved, raised, and turned by a rake, in order that the air may reach every point in succession, and effect a complete incineration.

To prevent the wind from dispersing the ashes, and creating disorder in the combustion, it is customary, in some places, to dig holes in the ground, in which they carry on the combustion; but this method, independent of being less economical, is also slower and more defective, inasmuch as the combustion is impeded in these holes, and a complete incineration is almost impossible.

Independent of the resources furnished by the unprofitable herbs of the field, the under-

wood by which some lands are exhausted, the plants collected in weeding, and the branches supplied by the pruning of trees, &c. recourse is also had to the cinders of the hearth: the manufacturer prefers the one or the other of these means, according to the situation. In some of the northern departments of France, where the forests cover a great part of the land, almost all the inhabitants of the country manufacture the ashes: the women and children collect decayed wood and burn it, the cinders are lixiviated in warm water, and the evaporation is conducted in small kettles, which do not contain more than 100 lbs. of this liquor. In the southern departments of France, where the wood is scarcely sufficient for domestic uses, the ashes are bought at private houses, and are manufactured in works built for the purpose.

Where it is intended to clear a forest, the establishment of a manufacture of potash is almost always advantageous, as it is the only means of applying to a profitable purpose, the small wood which will not serve for other uses; and this is the origin of the immense quantities of potash which are manufactured in America. In France, where this combustible is much less

abundant than in countries less advanced in civilization, and the manufactures consequently less numerous, immense forests are still found, where cultivation is impossible, owing to the want of a market; manufactories of potash have been established in some, and might, without inconvenience, be established in many others, if the manufacture were superintended in such a manner as might insure a good return.

Although the operations of the manufacturer be not the same in different works, the only variation consists in the manner of lixiviating the ashes, and of concentrating the lees.

Some lixiviate the ashes in cold and others in warm water: the former employ large quantities of water to exhaust the ashes, and on this account the evaporation must be long and expensive; the latter quickly obtain the water more highly impregnated, the ashes are more completely exhausted, and they manufacture more potash in a given time. The first method occasions more labour, requires a greater number of vessels, and occupies more time; the second consumes a little more fuel, in order to heat the water of lixiviation, but

shortens the operation. The manufacturer, however, must balance the advantages and the inconveniences of each method, and make his choice as his interest and situation may dictate.

In other respects, the lixiviation of the ashes should be conducted in the same manner as that of the nitrous earths: the vessels are ranged in several rows; they are filled with ashes, which are pressed in with the greatest care, being so arranged in the vessel that the water may penetrate slowly and equally: water is then added in quantity sufficient to cover the surface, and is suffered to remain during some hours, in order that the whole mass may be thoroughly infused, and the liquid completely impregnated with the salt. It is afterwards passed through a strainer.

As passing the water once through the ashes is not sufficient to deprive them of all their alkali, care is taken to pour fresh water on the ashes which have been already lixiviated, and this water is again employed in lixiviating fresh, or less exhausted ashes; so that, in the end, the lees acquire the strength of 12 or 15 degrees of Baume's aerometre.

I have seen manufactories of potash, where the steeping-vessels each contained 2500 lbs. of ashes. This size appeared to me too large; it is difficult to effect in them a perfect lixiviation. This inconvenience is but very partially remedied, by the practice of wetting the ashes as they are deposited in the vessel.

Some manufacturers employ foul, and often putrid waters, in the steeping of ashes. Kunckel maintains, that such waters produce a double quantity of potash. Admitting the truth of this observation, in certain instances, the augmentation of product can only be attributed to the quantity of alkali contained in the water.

When a quantity of lees, of the strength of 15 degrees, is collected, sufficiently large to prevent all apprehension of wanting a supply for the evaporation, the extraction of the salt is next undertaken.

This operation is performed in boilers of cast-iron, of a round form, from three to five feet in diameter, and from 18 to 20 inches deep.

Several of these boilers are placed over the same fire. In the northern departments, three

are placed together; in other departments they are extended to five.

There is also formed as near to the furnace as possible, a reservoir, sufficiently large and elevated to supply continually fresh lees, in order to replace the loss of liquid which is caused by the evaporation.

All the boilers are then filled with prepared lees, and heated to ebullition. A fresh quantity of lees is suffered to flow as the evaporation takes place, and the boiling is continued day and night

When the liquor is become of nearly the consistence of honey, it is transferred to the boiler which has the strongest heat: it is in this that the evaporation is finished, and the evaporation and addition of fresh lees is continued in the others

When the matter has thickened and acquired the consistence of which we have spoken, it readily swells, fixes, and forms a crust on the sides of the boiler. To obviate this inconvenience, care is taken to often agitate and stir the mass with iron shovels.

The ashes are known to be sufficiently dried, when the matter becomes moveable by the in-

strument used to agitate it, and when it assumes a solid form on cooling in the air. It is in this state poured into barrels, in which it soon becomes solid, and is in this form sent from the manufactory for delivery in commerce, under the name of potash.

In several manufactories, the evaporation is begun in copper boilers, and finished in boilers of iron. This method has the advantage of permitting the employment of evaporating vessels of a much greater capacity, and is particularly convenient in establishments at a great distance from iron founderies.

The ashes thus lixiviated, are still of marked use in the arts, and are known under the name *buck ashes*. 1. They may be used in the composition of bottle glass: a mixture of lixiviated ashes with about an equal quantity of a volcanic sand washed down by currents of water, and consisting of one third quarizous sand and two thirds volcanic productions, have for a long time supplied one of the most interesting manufactories of bottle glass which I know: 2. The ashes make an excellent manure for moist grass lands: 3. Cupels are made of them, which serve to separate gold and silver from their alloy with lead.

There prevails in most potash manufactories, a prejudice difficult to overcome: it is contended that old ashes produce more alkali than those which are fresh; and they are used in preference, when the means of the manufacturer allow him to form a store.

I have myself observed, that this opinion is, to a certain extent, well founded; not that the alkali is produced by length of time, but because it passes into the state of a carbonate, and by this means alone are its weight and bulk augmented; the alkali then indeed appears more abundant, but it is less pure.

It is also seen that, in some works, they proceed to a second lixiviation of the ashes, after having left them some time exposed to the air; but there would be no second product if the first lixiviation had been complete.

The potash most esteemed in commerce, is in general that which has a yellowish appearance.

Its quality varies not only according to the nature of the vegetables, but also according to the climate. The salts which are almost always mixt with it, are the muriates, and more especially the sulphates. When the vegetables

have been imperfectly burnt, there remains an extractive principle, which injures the quality.

Potash is very soluble in water. When pure, it attracts moisture from the air, and deliquesces. Its taste is sharp, acrid, and urinous; and it has a slightly empyreumatic odour.

Although potash is of most extensive use in the arts, and the manufacture of it might be established in almost every part of the empire, in order to use the ashes of our hearths, the unprofitable vegetables, or the timber of forests, where the means of cultivation fail; yet is this species of industry known in a few only of our departments. I have attempted to encourage this trade in the forests of Lozere and of Aveyron; and had, to this effect, formed an establishment of this kind at Saint Saviour, near to Meyrueis. This establishment prospered during six years, but the revolution occasioned the annihilation of it. I could wish the establishment were revived, as I know few situations better adapted to produce advantages of this kind.

It appears to me that the French government, which is tributary to strangers for a material which forms the base of the manufacto-

ries of soft soap, of glass, and of saltpetre, ought to endeavour to give a *popularity* to this kind of manufacture. I say *popularity*, because the materials of the manufacture are every where found; and it is only required to procure a tub, a small bucket, and an iron boiler, in order to manufacture potash. This portable apparatus may be fixed any where, and at small expence; and it would be particularly advantageous to make it known in mountainous countries, where it would furnish a very useful branch of industry to the inhabitants.

The potash, when whitened by calcination, is called *pearl ash.* This operation is always indispensible, when the alkali is intended for uses in which the colouring principle would be injurious; as in dying, in the refining of saltpetre, the seasoning of provisions, and the manufacture of alum.

The oven in which the calcination is performed, is a kind of reverberatory furnace, the flattened arch of which is only elevated about 15 inches in the middle above the floor of the oven. It is in general made from 11 to 12 feet long, and from 7 to 9 feet broad. The fire is placed at one end, and a few inches lower than

the level of the area of the oven. The chimney is built at the other extremity, and two openings are formed in the sides, in order to introduce the potash, agitate it during the calcination, and to take out the pearl-ash when it is made.

In Germany, furnaces are used which are six feet square, and divided into three compartments; the two exterior of which are occupied by the fire, and the intermediate one receives the mass to be calcined. A piece of cast-iron, or a small wall of bricks, about three inches thick, and seven or eight higher than the area, form the partitions A void space, of about five or six inches, is left between the partition and the wall of the furnace, through which the flame of the fires enters the oven: each of the compartments has a door to facilitate any operation in the interior of the furnace, but that of the oven is much larger than the two lateral doors of the fire-places.

Whatever may be the form of the furnace, the calcination is always carried on in the same manner. A strong fire is first applied till the vault has acquired a white heat; the oven is then cleaned, and four or five hundred weight

of potash are put into it. The matter is stirred from time to time, by means of an iron shovel, a rake, or bar of the same metal; and when it begins to form into a paste, and there remain no longer any black spots, it is withdrawn from the oven. In proportion as one workman empties the furnace, another supplies it with fresh salts; so that the process is never interrupted. Each operation continues about six hours.

The phenomena which present themselves during the calcination of potash, vary, according to its nature and degree of consistence. If it contain muriate of soda and sulphate of potash, a continual decrepitation is heard, which does not cease till these salts have lost their water of crystallization. If the potash be too moist, it assumes a liquid state on the first impression of the fire: in this case, when the superfluous water is dissipated, the salt forms a very compact crust, which must be broken and raised to promote its calcination: it is proper to observe, that when the potash has lost all its water, it kindles in an instant, and the colouring and extractive matters are consumed. At this time it must be turned, stirred, and changed, in order that the calcination may be equally

extended; and at the same moment the fire is moderated, and the alkali is kept at a low red heat. Without this precaution, a commencement of vitrification is occasioned, which renders the pearl-ash heavy, and sparingly soluble in water.

When the operation has been well conducted, the pearl ash is light, marked with blue and white, and sometimes green spots. Its taste is sharp and caustic; it forms into a paste in the air, and is easily soluble in water.

Pearl-ash always contains, in a greater or less quantity, salts and other foreign matters. Its fracture ought to present a white surface, which is a proof that the calcination has been complete.

It ought to soften in the air: when it remains dry and compact, it is a proof that it either contains a great quantity of salts, or has been too strongly calcined.

Potash loses, in calcination, from 10 to 25 per cent. of its weight.

As soon as this alkali is drawn from the furnace, it is put into barrels, for the convenience of trade.

Almost all the potash of the north of Eu-

rope is exported from Dantzic, and bears the name of this place. That which comes from America is called American potash.

As the potashes vary very much and present themselves in different degrees of goodness, it must be highly important to the artist or manufacturer to possess an easy mean of ascertaining its purity, not only that he may have certain rules to guide him in his purchases, but also in order that he may employ in his operations, a substance well understood, and of a known degree of strength We will proceed to mention, on this subject, all that is easily executed, and may be supposed within the power of the artist and manufacturer.

If, therefore, it be desired to ascertain the quantity of pure alkali contained in a definite weight of potash, it is not sufficient to dissolve the potash of the experiment in an adequate quantity of water, and to infer that the alkali is abundant in proportion as the water acquires a greater density; for M. Vauquelin has observed, that water acquires more density from potash weakly impregnated with alkali, than from that which contains it more richly.

M. Vauquelin recommends the use of nitric

acid in ascertaining the strength of potashes: for this purpose, we should first ascertain the quantity of pure alkali which a certain weight of nitric acid is capable of holding in solution. Acid of the same degree of strength is then employed, in a quantity sufficient to saturate all the alkali contained in a given weight of potash, and the quantity of alkali present is inferred from that of the acid required in this saturation. Instead of employing nitric acid, we may use either the muriatic or acetic; and whichever of the three may be preferred, the desired result will always be obtained.

In order to determine afterwards the proportions of sulphate and muriate of potash, when the alkali is saturated with nitric acid, the nitrate of barytes is added to decompose the sulphate of potash: the quantity of precipitated sulphate of barytes which is obtained, indicates about half its weight of sulphate of potash, and about 28 hundredth parts of alkali, contained in the latter. The nitrate of silver decomposes the muriatic salts, and in like manner discovers their proportions.

By processes similar to these, M. Vauquelin examined six kinds of potash, the most known

in commerce. We will here state the results of his analyses, in which he employed 1152 parts of each.

Kind of Potash.	Quantity of real Potash or Alkali.	Sulphate of Potash.	Muriate of Potash.	Insoluble Residue.	Carbonic Acid and Water.
Russian Potash . . .	772	65	5	56	254
American ditto . . .	857	154	20	2	119
Pearl-ash	754	80	4	6	308
Potash of Treves . . .	72	165	44	24	199
Ditto of Dantzick . .	605	152	14	79	304
Ditto of Vosges . .	444	148	510	34	304

M. Westrumb has proposed a new method of examining potashes, which unites accuracy with simplicity. A certain measure of solution of potash is poured into a glass vessel; the same measure is then filled with sulphuric acid, which is constantly used of the same degree of strength, in order that the results of the examinations of different potashes, may admit of accurate comparison: this measure is mixed with the measure of alkaline solution, and agitated with a glass rod; a drop of the liquor is then applied by the end of the rod to stained litmus paper, on which a trace is made; or, in

preference, a small slip of the paper is plunged in the liquid. If the paper do not redden, a certain portion of the proof acid is poured into the first mixture; it is again agitated, and tested by the paper as before. If the paper do not yet become red, the addition of a fresh quantity of acid is repeated, and continued till the litmus paper reddens. It is evident, that the acid employed to saturate the measure of alkali, must be in proportion to the quantity of alkali it contains; and that the goodness of potashes and soda may be precisely estimated by the respective quantities of acid which they neutralize.

It is superfluous to remark, that, in order to establish accurate calculations, it is necessary to operate upon solutions prepared in large quantity, and always with the same weight of alkali and equal measures of water.

In order that the acid employed in the examinations may always be of an equal standard, enough of it is prepared for the use of several years, and preserved in bottles.

M. Welter dissolves the potash by suspending it at the surface of the water, in a vessel of iron pierced with a great number of holes, or

formed of large iron wire: the lee is not tested till the solution is complete, and the liquor has been well agitated.

The ashes produced by the combustion of wine lees, form an alkali known in commerce to glass and soap-makers, by the name of *scobs*.

This manufacture has been hitherto confined almost exclusively to a small number of individuals, favourably situated in neighbourhoods where the vine is most abundantly produced. Thus in all the south of France, I know only one manufacture of this salt established at the port of Cette, where are deposited, or from whence are exported, almost all the wines of these southern countries.

To effect the combustion of the wine-lees, they must previously be properly dried: this first operation is performed either by a very powerful pressure to which the mass is subjected, or by mere exposure to the air and sun in suitable vessels. When the first method is employed, the expressed juice may be converted into vinegar, or be distilled to extract the brandy: when the lee is well dried, it is formed into masses of the size of a loaf, to facilitate its combustion.

The lees which break short and with noise, may be burnt in this state; but it is necessary sometimes, in order to produce this degree of dryness, to have recourse to the heat of a stove.

There are various methods of conducting this combustion. In one place, a round furnace is used five or six feet in diameter, which is raised by dry stones, in proportion as the combustion takes place and the space is filled by the residue: in another, the furnace is fixed, and the current of air depends upon an opening made at the bottom. In both cases, it is necessary to begin with heating the furnace, by burning in it faggots of vine branches, or any other light combustible The lee thoroughly dried, is next thrown in; and, when kindled, it is left to burn without stirring. The fire is fed by throwing in fresh cakes of lee; so that the fire is supported till the furnace is filled by the porous residue of combustion. This residue forms a light spongy mass, breaks easily, and upon cooling, which is suffered to take place in the furnace, assumes a greenish colour mixed with blue.

In order that these ashes may possess all the properties which in the arts are attributed to

them, it is necessary that the combustion be complete: if it be imperfect, the ashes will communicate a yellow tinge to water, and a green one to the colour of indigo; a circumstance which renders it unfit to be employed in making a solution of that substance.

The wine-lees have never yielded me more than a twenty-fifth part in good ashes.

This alkali excites a strong and rather burning sensation on the tongue: it is almost entirely soluble in water. Its fracture ought not to present any black spot; and when, in withdrawing the ashes from the furnace, any patches of black, or parts ill burnt, are perceived, they are carefully separated, to be subjected to a second combustion.

The ashes of wine-lees are reputed, in commerce, to contain the purest alkali, and that in particular, whose quality is least subject to variation; and it is accordingly employed, by preference, in certain delicate operations, as in the preparation of indigo, and certain compositions in dying.

An analysis of this alkali, which had been prepared with greatest care, afforded me a sixteenth part only of insoluble matter, con-

sisting of a mixture of one quarter sulphate of potass, and three quarters earthy substances and salts, such as carbonate of lime, magnesia, and a little alumine.

Scheel has proved that the colour which alkalies acquire during calcination is owing to a small quantity of manganese.

The other parts of the grape, such as the stalk and the husk, and the residue of the distillation of wines known by the name of *vinasse*, the deposit of tartar on the sides of the casks, afford us further great resources for procuring the alkali.

The stalks of the grape, formerly employed in the south of France in the manufacture of verdigris, are no longer any where made use of. They are thrown away, almost every where, as the grapes are plucked off. They might, nevertheless, be burnt with advantage as the lees of their ashes produce one quarter of good alkali.

The husk of the grape is still richer in alkali than the stalk: it is well known that its combustion produces a large quantity. When it is withdrawn from the wine-press, it must be exposed in the open air, and often turned, in

order to dry it. It may be burnt in common furnaces, and thus advantage may at the same time be derived from the heat and from the ashes produced by the combustion.

Attention must be paid not to suffer the husk to ferment before it is dried: for I have remarked that in this case it not only burns with greater difficulty, but it also yields less alkali.

The husks, in general, afford a twenty-fifth part in pure alkali.

In the numerous distilleries of brandy, when the distillation of the wine, from which is extracted the inflammable and spirituous principle, has been continued sufficiently long, what remains in the still is rejected, under the name of *vinasse*. This residue, exposed to the air in a vessel, deposits tartar and wine lees; and, after drying by evaporation, the combustion yields an alkali.

A very pure alkali is also obtained from the combustion of tartar.

Tartar is deposited on the sides of the casks in which wines are kept, and is contained in the wines, in greater or less abundance.

The colour of this salt varies, depending on that of the wine, whether it be red or white.

This salt is sparingly soluble in cold water; but is soluble in larger quantity in warm.

When disengaged from its colouring principle, it forms the cream of tartar.

In some countries, where the manufacture of the cream of tartar is not known, the salt possesses scarcely any value. It is only sold in very small quantities to dyers, to the apothecary, or to founders.

When the agriculturist shall have learnt that he may extract a valuable alkali by the combustion of tartar, he will probably no longer decline so profitable a branch of industry.

Chemists recommend to pound the tartar, and to fill small packets of paper with it, to wet the papers and place them in the fire, in the middle of the red coals, in order to effect the combustion. The coal of the tartar preserves the form of the paper, and it may be withdrawn in this state after the operation.

This process is certainly well adapted for the preparation of any small quantities of salt of tartar for the uses of pharmacy; but if it be intended to operate upon a larger scale, it is necessary to adopt a method similar to that we

have spoken of in the manufacture of alkali from wine lees.

Tartar leaves, after the process of burning, about one quarter of its weight.

For the purposes of pharmacy, the tartar is lixiviated, and the solution is filtered and evaporated, to obtain the white and in a considerable degree pure salt, known by the name of *salt of tartar*.

We shall direct our attention to the means of obtaining the potash in its highest degree of purity, after having treated of soda; the processes usually adopted, under similar circumstances, being common to both these alkalies.

XII. *Of Soda.*

Soda resembles potash in the qualities which characterise the alkalies; but it differs from this essentially, in not forming with the same bases, similar compounds, and in suffering or procuring very different effects in the air, in water, or upon the taste, &c.

This alkali has also been denominated *mi-*

neral alkali, because it was regarded as the result of a decomposition of sea salt, inasmuch as it is invariably afforded by the combustion of marine plants.

The analysis of some stones has, however, detected its existence in several mineral substances.

M. Klaproth found 1,75 of soda in an analysis of the *pechstein* of Meissen. The Lipari stone furnished him with three parts in a hundred.

Dr. Kennedy has discovered it in analyzing the basaltes on which the castle of Edinburgh stands.

Almost all the soda of commerce is the product of the combustion of marine plants. The quality varies according to the nature of the plant and the climate. The names given to the different sodas of commerce, are generally those of the plant which furnishes it, or of the country whence it is procured. We shall describe the principal sorts, because each has its particular applications, which cannot without difficulty be interchanged, because one cannot be substituted for the other till after examinations, ruinous trials and attempts, and

because foreign matters are often combined in certain kinds of soda, which render them unfit for many operations.

The sodas which are brought from Spain are the most valuable: they bear the names of soda of *Alicant*, of *Carthagena*, and of *Malaga*.

The soda of Alicant is known also under the name of *barilla*, that is, under the name of the plant which furnishes it.

The celebrated Linnæus describes the barilla by the following characters: *Salsola vermiculata, frutescens, foliis ovatis, acutis, carnosis.* This plant is cultivated with attention on the Spanish shores of the Mediterranean; it is sown and gathered every year; it is burnt in the open air, in cavities dug three feet deep and four broad, in a very dry soil, and the combustion is supported several days; the residue is a mass which is hard, compact, and almost vitreous, which is broken into large fragments, in order to be carried away; these fragments are then packed in mats and formed into bales, weighing from 4 to 5 cwt.

These fragments or *stones* of soda, of which the surface is black and the interior of a

greyish colour, break with noise by the stroke of any hard body; the angles are sharp and cutting; the fracture presents the same appearance of bubbles as the porous lava, to which it approaches also in colour. The taste is alkaline, without being sharp; and friction disengages a very strong odour of sulphuretted hydrogen gas.

The analysis made by Mr Kirwan of the Spanish soda, yielded him the following products:

Carbonic acid	960	
Carbon	861	— 82
Lime	542	— 86
Magnesia	127	
Alumine	131	— 23
Silex	249	— 58
Soda	1219	
Sulphate of soda	125	
Muriate of soda	70	
Water	1453	— 51
Deposited earth	20	

The results of my own analyses do not present the same proportions. This difference

proceeds, no doubt, from the very variable nature of the sodas. I employed in my examinations the soda of Alicant, which is especially known by the name of barilla.

One hundred parts of barilla carefully pounded, to which four times that weight of water was added, after filtration, yielded in the first evaporation carried on to 38 degrees, 15,00 crystals of soda, 17,05 muriate of soda, and 5,00 sulphate: the bitter waters mixed with water sufficient to dissolve the residue of this saline substance, and concentrated by evaporation, gave 35,00 crystals unmixed with muriate of soda. The crystals of soda dried in the air lost 29,00, which reduces the total quantity of them to 21,00 of dry crystals. The insoluble residue weighed 49,00, and consisted of 22,13 magnesia, 19,00 lime, 5,97 silex, and a small portion of oxide of iron.

Three kinds of soda are manufactured on the coast of Alicant. One is called *mild soda, mild barilla*, or *soda of the first quality:* this has a cineritious appearance, seems best melted, and presents the fracture and appearance of the scum of sulphur. Its price is one quarter more than that of the others, and it is in par-

ticular request for the manufacture of crystal and flint glasses. Its solution in water remains for some time cloudy.

The second quality is called *mixed soda or barilla;* it is very hard, its fracture clean, its appearance somewhat black, and the interior is filled with cells or bubbles. Its taste is rather peculiar. It dissolves with difficulty in water; and is chiefly employed in the manufacture of soap and in dyeing cottons.

The third quality is called *bourde;* this contains much marine salt, and is filled with light coals, which rise to the surface during its solution. It is obtained by burning plants promiscuously gathered.

The soda of *Carthagena* holds the first rank, after the second quality of barilla, which it resembles much in its colour: its quality is superior to that of the bourde.

The soda of Alicant is an object of first necessity in our manufactures. Whenever war has interrupted our intercourse with Spain, we have aways experienced much embarrassment. It has been supposed that we might easily deliver ourselves from this dependence, by cultivating the barilla on our shores of the

Mediterranean. So early as the commencement of the eighteenth century, the states of Languedoc had encouraged the culture of it, and the first essays made at Frontignan were attended with satisfactory results; but the undertaking appears to have been neglected, and there remained of these first experiments nothing but the certainty that they had been successful.

In 1782, I induced one of my friends, M. Pouget, lieutenant-general of the admiralty at Cette, to join with me in a repetition of these experiments. The marshal de Castres, at that time minister of the marine, procured for us 4lb. of barilla seed, which we sowed on ground well prepared, upon the strand of Frontignan. The waters and the animals which frequented the place, diminished very much the produce of our harvest; we nevertheless obtained by combustion a tolerable large quantity of good soda; and reserved at least a third of the crop, in order to obtain the seed we might desire for the following year. An analysis of the soda afforded me nearly the same products as that of Alicant. These essays were repeated during three years, nor did we perceive that the

barilla had in the least degenerated. M. Pouget was called to Paris, to attend upon the minister; and not being able any longer to conduct or superintend the culture himself, it fell a second time into neglect, after having afforded us a proof that the soil and climate of the shores of the Mediterranean are highly favourable to it.

The *salicor*, or *soda of Narbonne*, is the product of the combustion of a plant, which is cultivated under the name of *salicor*, on the shores of Narbonne. It is known to botanists by the name of *salicornia annua*: it is sown and gathered the same year. It is cut after the season of its fructification; it is collected in heaps near the places where the combustion is to be conducted, and is burnt in deep holes, as we have already remarked in speaking of barilla.

This soda is distributed in commerce in masses of 3 or 400lb.

It is employed principally in those glass-works which melt the green glass.

In commerce it ranks next to the Spanish sodas.

An analysis of it yielded me in 100 parts:

Sulphate of soda	9,00
Muriate of soda	19,00
Soda in dry crystals . . .	14,33
Lime	5,06
Magnesia	16,88
Silex	9,80
Carbonic acid	15,00
Carbon	10,91

Blanquete, or *soda of Aiguemortes*, is cultivated between Frontignan and Aiguemortes, on the shores of the Mediterranean. They burn every year, towards the close of the summer, all the saline plants which grow there spontaneously: the peasants search wherever any such are to be found; they mow and collect them in heaps, in order to burn them in the trenches, as we have already related respecting the other kinds of soda. The burning is continued eight or nine days; the residue forms an adhesive and almost vitreous mass, which remains at a red heat during the combustion, and which hardens and becomes black on cooling. The product of each operation amounts to 8 or 900lb. of soda.

This soda, extensively used in the south of France, is the product of the combustion of the *salicornia europea*, the *salsola tragus*, the *statice limonium*, the *atriplex portulacoides*, and of the *salsola kali*.

According to an analysis which I have made of these plants, the *salicornia europea* affords the most soda; and next to it, the *atriplex portulacoides*. That which affords the least is the *statice limonium*. All of them abound in sea salt; and the pure soda does not exist in them in greater proportion than from 4 to 10 per cwt.

While France laboured under the burdens of the salt tax, the manufacturers of green glass derived a great advantage from the use of this soda, because, the salt rising when melted to the surface of the pots, was carefully collected and made an article of commerce. The consumption of this alkali has much diminished since the suppression of the *gabelle* has destroyed this source of advantage.

The *varec (wrack)*, or *soda of Normandy*, receives its name from the plants that supply it, or from the country in which it is manu-

factured. These plants are of the *fucus* genus, and grow abundantly on the shores of the ocean.

In order to effect the combustion of them, they are dried and burnt according to the processes we have already described. Macquer, who has analyzed the wrack-weed, found no indication of a free alkali before the incineration; and he presumes that the alkali found in the Varec soda, proceeds from the decomposition of a portion of the neutral salts, the sulphates and muriates of soda, which the plant contains in abundance. Exclusive of the analysis of the plant, which afforded no uncombined soda, Macquer instances, as a proof of his assertion, the formation and developement of sulphureous acid, of sulphur, and of sulphuretted alkali, during the operation of combustion.

Exclusive of the substances of which we have spoken, there exists in the residue of the burning of the plant, called *soda of Varec*, portions of sulphate and muriate of potash. Macquer found soda only in the proportion of $\frac{1}{69}$ of the total quantity. He thinks it would be possible to produce an analogous soda, by mixing

the sulphate and the muriate with powdered charcoal, and strongly calcining the mixture. He proposes, in order to increase the proportion of alkali, not to use this soda till it has been subjected to a previous calcination.

The *natrom*, or *natron*, is gathered in many parts of Egypt, from whence it is circulated in commerce.

MM. Sicard and Volney have given us descriptions of two lakes which supply it: they are situated in the desert of Thaiat, or Saint-Macaire, to the west of Delta. Their bed forms a valley from three to four leagues in length, and a quarter of a league broad; the bottom is solid and rocky. These lakes are dry during nine months in the year; but, in winter, a reddish violet-coloured water oozes in and fills the lake to the depth of five or six feet, but the return of the hot season evaporates it, and there remains a stratum of natron, which they detach by means of iron bars.

Natron is of a dirty brown grey colour. Its taste is salt; it grates between the teeth, and leaves the impression of common salt with a mixture of bitter. The surface of the pieces of natron sold in commerce, appears chased, or

as if formed of bubbles; its fracture is grey and granular; its fragments possess a slight transparency. It becomes opaque when placed on a red coal, and the small particles decrepitate.

M. Berthollet, who has had an opportunity of visiting the natron lakes of Egypt, has furnished us with a very satisfactory theory of the formation of this substance. All the soils where this salt is found, are impregnated with sea-salt: where the soil is argillaceous, muriate of soda and a small quantity of carbonate of soda only, are found on the surface: where the soil, on the contrary, contains much carbonate of lime, if it be moist, and supply, at the same time, muriate of soda, there will be found also much carbonate of soda: whence M. Berthollet infers, that in those lakes the muriate of soda is decomposed by means of the carbonate of lime, the action of which is promoted by the moisture of the soil.

This theory is in perfect harmony with all the observations which have hitherto been made, in every situation where natron is produced.

When lime is slaked by water weakly im-

pregnated with sea-salt, after the lapse of some time, a carbonate of soda effloresces on the surface of the lime.

Natron is always formed wherever the marine salts are found mixed with carbonate of lime.

Natron is, in almost all instances, accompanied by sulphate of soda, which also appears to furnish this alkali by decomposition.

In ascending the small river the Lez, which flows by Montpellier, I have found numerous efflorescences of natron upon the soft rocks which form the banks of the river. I have found a great deal of it upon the walls of Grasse and Draguignan, in Provence: I have also met with it in great abundance in the subterraneous caverns of the fort of Salse, near to Perpignan. Pallas has described several situations in Siberia where the natron effloresces in abundance. M. Morell, of Berne, has given an account of a mixture of soda and sulphate of soda, in a mountain situated near to Swarzbourg; he has found it also in the quarries of Ochotzk.

The walls of Dieppe, of Fecamp, and of Havre, present every where traces of it.

Much soda is also obtained in the county of Bihar, in Hungary: the principal lakes which furnish it, are situated between Dobrezen and Grosswardein.

These lakes have received the name of *Feyrto*, or *white lakes*, on account of the whiteness of their sand during the summer when they are dry: this colour proceeds from the efflorescence of the natron.

This soda, which has been collected in times beyond record, is more especially employed in the numerous manufactures of soap at Dobrezen.

Ruckert observes, that the sand at the bottom of the lakes is somewhat ferruginous. I have seen, in confirmation of this observation, that the soft rocks in which natron is found, contain also some iron; so that the oxidation of this metal, and its action upon the muriatic or sulphuric acids, concur in separating the natron, and in facilitating an exchange of acidifiable bases.

It appears that the mere process of vegetation is capable of decomposing the sea-salt; inasmuch as the plants which grow on saline soils, furnish the soda by their combustion.

There are some which afford the sulphate of soda; such, for example, as the Tamarisc.

But in all instances, some time and a degree of maturity are required for the plants to furnish these salts; for if they are burnt before the vegetation of the year be terminated, they scarcely yield either soda or sulphate.

Extraction of Soda from Marine Salt, and from Sulphate of Soda.

We can by various processes extract the soda directly from the sea-salt.

The first, which I have practised on a very large scale, in my chemical manufactory established at Montpellier, is confined to the following processes:

Four hundred parts of sifted litharge are taken and divided in equal portions into stone-ware vessels, and 100 parts of marine salt are at the same time dissolved in 400 parts of water. One quarter of this solution is poured into the vessels, in order to form a paste with the litharge. As soon as the litharge is perceived to become white, which takes place some hours

after the mixture is made, the paste is stirred with a spatula, and the remainder of the solution of salt is added to it by degrees. Without this precaution, the paste thickens and becomes indurated, and the decomposition is incomplete. When the solution of salt appears insufficient, pure water is added towards the end of the operation.

If the operation has been well conducted, the decomposition takes place in the space of twenty-four hours ; and the result is an homogeneous uniform paste, the bulk of which is much more considerable than that of the water and litharge which have been employed.

To obtain a still more complete effect, the paste is suffered to remain twenty-four hours longer in the vessel.

The muriatic acid being detached and united to the lead, the soda is now in a caustic state. It is separated by pouring boiling water upon the paste, and duly agitating the mixture. Part of the liquor is separated by decanting, and the remainder by expression.

This operation is the more economical, on account of the advantage derived from the uses of the muriate of lead in the arts.

1. Calcination and fusion impart to this muriate a beautiful yellow colour, which may be successfully employed in painting. 2. The addition of a small quantity of very dilute sulphuric acid, communicates to it a beautiful white colour, and reduces it to a state of extremely minute division. This sulphate, when washed and dried, may be substituted for ceruse or white lead. It has no other disadvantage than that of being too light, and of not supplying a sufficient body of colour to the pencil of the artist, which is, however, sufficient to render the use of it more troublesome. This sulphate decomposed by potash, yields an oxide extremely white and heavy, and which may be successfully used in painting cloth or furniture. 3. The muriate of ~~soda~~ Lead may be decomposed by charcoal, and thus restore the whole of the metal which it contains.

This process for extracting the soda, might be adopted near the founderies of lead-mines, where it is necessary to convert the lead into litharge, in order to extract the silver with which it is alloyed. The litharge would serve for the purpose of decomposing the sea-salt, and the muriate of lead might afterwards be

subjected to the process of the furnace, to separate the metal.

The second method, proposed by MM. Carny and Guyton, consists in slaking lime with water, and adding afterwards a saturated solution of sea-salt, so as to form a paste. This paste is exposed in a moist situation. The soda effloresces after some days, into the state of carbonate; and this salt is collected in proportion as it forms. This operation continues till the salt is wholly decomposed.

The greatest advantage has been found in the decomposition of the sulphate of soda; and MM. Leblanc, Dizé, Alban, Bourlier, &c. have made known to this effect, processes which are more or less economical.

MM. Leblanc and Dizé mix and pound 1000 parts of sulphate of soda with 550 of charcoal, adding 1000 of purified chalk of Meudon. The chalk is not added till the mixture of the two first substances has been effected.

The mixture is then transferred to a reverberatory furnace heated to redness; it is stirred with an iron rake, and sulphuretted hydrogen gas is observed to disengage itself in flame. The raking is repeated as long as the ebullition

continues. The paste then becomes more fluid; and when its grain has acquired an homogeneous appearance, it is withdrawn from the furnace, and carried to a situation somewhat moist, in order to facilitate the efflorescence, and to favour the extrication of all the sulphuretted gas.

The inventors of this process, conducted on a large scale in their manufactory at St. Dennis, produce three kinds of soda for commerce: 1. Crude soda, or such as is found after efflorescence in their works; 2. Crystals of soda, procured by the lixiviation of the first kind; 3. The residue of the bitter waters evaporated and calcined.

The analysis of this soda by MM. Darcet, Pelletier, and Lelievre, yielded—

		lb.	oz.	gr.
In 5 lb.	Carbonate of soda . . .	1	14	0
	Pure soda	0	15	$\frac{5}{8}$
	Muriate of soda . . .	0	2	$\frac{7}{8}$
	Earthy residue, composed of 86,00 chalk, 12,00 sulphur, 1,00 charcoal.			

It is easy to perceive, that the difference between the quantity of soda employed and the sum of the extracted products, arises from the

water of crystallization furnished in the operations of the analysis.

M. Alban, conductor of the manufactory at Javelle, effects the decomposition of the sulphate of soda in the following manner: 200 parts of the calcined sulphate are mixed with 40 parts of charcoal in powder; a reverberatory furnace is filled with this mixture, care being previously taken that the furnace be well heated. The furnace is then closed, the fire continued, and the matter stirred by the rake. When the mixture is well fused, 40 parts of iron filings are added, and the whole is raised by the rake: the mixture which was melted and liquid, now thickens, boils, swells, and is covered with froth; the iron is very soon dissolved: about 16 lb. of glowing charcoal are then added, and agitation is repeated; a disengagement of sulphuretted hydrogen is observed; and 25 parts of fresh iron clippings, and 6 of charcoal, are added; and as soon as the disengagement of hydrogen is no longer perceptible, the mass is drawn off by suffering it to flow on the ground. The operation continues about three hours; the product in soda as it passes from the furnace, is 215 parts of the whole: it in-

creases three eighths of its weight by mere exposure to the air, and it crumbles and falls into powder.

The analysis of this soda produced, in the hundred pounds—

	lb.	oz.
Crystals of soda	71	4
Soda, partly caustic and partly aerated,	22	11
Sulphate of iron, with a portion of charcoal	6	1

This soda cannot be employed in several of the purposes for which the natural soda is used: it contains sulphur, which combines with the metals and forms sulphurets; and when it is dissolved in water, exhales a marked odour of sulphuretted hydrogen gas. These inconveniences may however be obviated, by dissolving and then crystallizing it. By these means a pure carbonate is obtained, well adapted to every purpose. The soda may also be freed of all its sulphur, by careful agitation, increasing a little the quantity of charcoal, and by prolonging a little the operation.

MM. Bourlier and Pluvinet, who, in their manufacture of sal ammoniac, produce a great quantity of sulphate of soda, decompose the

latter in such a manner as to obtain a soda which is preferred in commerce to all kinds that were before known.

M. Carny has formed an establishment near the salt-works in Franche-Comté, in order to decompose the sulphate of soda, which is extracted from the salt waters during their evaporation, and to obtain the soda. His products are already favourably received in commerce.

Exclusive of these processes for the decomposition of the muriates and sulphates of soda, the doctrine of double affinities may also be resorted to; if, for example, the pyro-lignates or the acetates, either of lead or of barytes, be mixed with a solution of the muriate or the sulphate of soda, the lignate or acetate of soda is obtained, and may be evaporated and calcined, in order to detach the acid, and procure the soda separately.

The soda which is obtained by processes in which iron or lime are introduced, requires to be carefully purified before it can be used without danger in the delicate operations of dyeing, especially if it be employed immediately before or after immersion in the infusion of galls,

In consequence of the small portion of iron which may remain, the colours are converted into black; they become, on the contrary, wine-red, when lime has been employed to effect the decomposition.

The soda and the potash, as found in commerce, are never of a degree of purity which admits of their being used in delicate operations or analyses.

The strong affinity to the alkalies which the carbonic acid exerts, and the presence of this acid almost every where, are the causes that these substances rarely exist uncombined with it. On the other hand, the carbon, the salts, the earths, and the metals contained in the vegetables, mix themselves with the alkali, and analysis demonstrates to us the existence in it of all these substances.

Among the number of matters properly speaking foreign to the alkalies, there are some soluble in water, and others which are not in any degree; so that, by dissolving the alkali in pure water, and filtering the solution with care, we separate from it the earths, the carbon, and the metals, and it remains mixed with soluble salts. The alkali may next be separated from

these by evaporation; because, owing to their less solubility, these crystallize the first. But, by these processes, the alkalies are never obtained pure; and chemists have been obliged to employ, for this purpose, more accurate methods.

In order to separate the carbonic acid from the alkali with which it is constantly united, quicklime is used, which has the property of abstracting the acid. It is sufficient for this purpose, to mix the alkali and the lime in equal parts; and indeed lime must only be employed in the proportion of one half when we operate upon the alkalies of commerce. The mixture is made with lime well pounded, or brought into a state of extreme division by means of a small quantity of water. In both cases, the mixture is well agitated, and formed into a liquid paste: it is next filtered, and the residue is strongly pressed to extract all the liquid. The alkali, deprived of its acid, has a caustic burning taste, while the lime, having passed again into the state of carbonate, has recovered its insolubility and the other characters of chalk.

These caustic alkalies concentrated, dried, fused, and cast in moulds, cauterize or dissolve

animal matters, and form what is called the *caustic stone*. They absorb water with great avidity, attract the moisture of the atmosphere, and melt in deliquescence; and, on account of this property, potash reduced to this state was called *oil of tartar per deliq.*

When soda and potash are employed in the operations of the arts, it is often necessary to render them caustic to increase their action, as is practised in the soap-manufactories.

Nevertheless, the alkalies cannot yet be regarded as pure, or as fit to be used in the delicate operations of chemistry, in which it is of importance to employ none but pure substances, in order better to ascertain their properties, and to render much less complicated the results of their action. It is on this account that other means have been devised of obtaining the alkalies absolutely pure, which has been effected in the following manner:

The caustic alkaline solution is concentrated till it acquires some degree of consistence; it is then mixed with pure alcohol, and a part is drawn off by distillation. On cooling merely, crystals form in the bottom of the vessels, and in the midst of a dark-brown aqueous liquor:

these crystals are a carbonate of the alkali, which is insoluble in the alcohol. A further dark deposit is obtained, consisting of all the extraneous earths of the alkali: the liquor which floats above, and forms an oily coat at the surface, is pure alcohol, holding very pure alkali in solution. The alcohol is then concentrated, and the alkali obtained pure, in crystals or in plates, according to the degree of evaporation.

When the operations of art require the use of alkali more pure than those of commerce, it is customary, by a solution and filtration of these, to separate a great proportion of the salts, earths, and metals, which may be found in them. The solution is concentrated by evaporation; and when soda is the matter operated upon, crystals are obtained, which are known in the arts under the names of *salt of soda* and *carbonate of soda*. When the acquisition of potash is the object, it is thought sufficient to concentrate it to dryness, or otherwise carbonic acid is made to pass into the solution, to reduce the alkali to the state of a carbonate, and impart to it the property of crystallizing.

The carbonate of soda effloresces in the air,

that of potash preserves its form and consistence.

The carbonate of soda crystallizes in the form of an octahedron with rhomboid bases. 100 parts contain 16 acid, 20 alkali, and 64 water.

The crystals of carbonate of potash are tetrahedral prisms, terminated by very flat pyramids with four faces.

They contain in 100 parts, 20 acid, 48 alkali, and 32 water, according to Bergmann.

It has long been a disputed question, whether the alkalies exist already formed in vegetables, or are the product of incineration. This question remains still undecided.

Duhamel and Grosse had already proved in 1732, that potash exists in cream of tartar; and after them, Margraaf, Rouelle, and Bullion, have added new facts to those already known.

M. Vauquelin concludes, from his analysis of the *salsola soda*, that the fire only separates the soda which exists already in the plant.

Much has also been written respecting the nature of the constituent principles of these two alkalies: some supposing that chalk forms the base of potash, and magnesia that of soda:

others have regarded azot as the alkaligenous principle. Some have attributed their formation to the fixation of hydrogen with an earthy base; but these suppositions, as soon as advanced, were contradicted by more accurate experiments; and we remain still in perfect ignorance of the constituent nature of the fixed alkalies. M. Vauquelin, in contradiction to Dehné, Lorgna, &c. has proved that pure soda does not yield the least magnesia by analysis. (*Annales de Chimie*, July, 1793.)

The same chemist has demonstrated the most exact analogy between the products of the salsola soda and those of animal bodies. He extracted from this plant, prussic acid and ammoniacal gas. This observation, and all the phenomena which attend the formation of this alkali, should lead us to believe, that this alkali has an animal origin, while potash has a vegetable one.

The alkalies, although existing in vegetables, are not found in them pure, and disengaged from all combination. They form a kind of soap with the oils, and facilitate the circulation of them in the vegetable; they also exist in them combined with the acids and the earths;

hence result combinations which heat alone can destroy, and which explains the effect of combustion in yielding them in a free state.

Theory of the Caustics.

That property is called *causticity*, which some bodies possess of corroding, inflaming, or destroying that part of the skin to which they are applied.

Lemery attributed this effect to the igneous particles interspersed and imbibed in the pores, which admit the entrance of the caustic particles.

Meyer of Osnabruck has given to this supposition all the weight it could receive from an infinite number of experiments made upon lime and the alkalies; and he attributes causticity to the matter of fire, united to subtle acid, which he calls *acidum pingue causticum*. He watched the transition of this principle from one body to another, and found that causticity was its inseparable characteristic.

Several chemists have embraced and supported this opinion. Beaumé especially has

referred to pure fire, not only the cause of causticity, but that of taste also, which appears to him to be one of the first degrees of it.

Dr. Black, of Edinburgh, has since demonstrated that lime of the alkalies only become caustic as they are deprived of the carbonic acid, that they cease to be so when this is restored to them, and that they are so, more or less, according to the quantity which they retain; whence he concludes, that the absence of this substance regulates causticity, which may at pleasure be imparted to lime or the alkalies, by depriving them of this acid.

Macquer supporting himself on these facts, attempts to overturn the system of fire, and to maintain that causticity is only a tendency to combination. Nevertheless this chemist does not deny that several facts appear favourable to the doctrine of fire. 1. Caustics evolve much heat during their action. 2. When entering into combination with acidifiable or other bases, according to the nature of them, much more heat is produced than when they are not caustic. But he finds an answer to these objections in the collision of parts caused by the action of caustics, from which collision,

according to him, the heat results, and the effervescence produced by the action of the acids upon chalk and the non-caustic alkalies, which effervescence carries off the heat, and leaves reason to believe that there is as much of it contained in the substances when mild, as there is in them when caustic. This chemist would be much embarrassed to explain why the solution of almost all caustics in water disengages much heat, while none is produced when they are not caustic.

The error of Macquer arises from his not having perceived, 1. That when chalk or an alkali are deprived of carbonic acid, they receive caloric in exchange; 2. That the caloric is in a state of combination, and that consequently he could not observe any variation of the thermometer in the caustic or the non-caustic substances; 3. That the fluid of heat disengages itself as soon as another principle is combined with the caustic; 4. That the caustic alkali or lime, although diluted to a certain degree in water, preserve more causticity than the carbonates of lime or alkali when much concentrated.

Nevertheless, the idea advanced by Macquer

in attributing the cause of causticity to the effort or tendency to combination, naturally connects itself with the doctrine of caustics: in effect they do not act, excepting in so far as they can enter into combination. Thus a hot substance, a stone reddened in the fire, will transmit its excess of heat, and produce on the body the effect of burning; an alkali penetrated by the same quantity of heat, as lime will form a much more powerful caustic than the lime, because its solvent effect upon the skin is much more marked. Concentrated sulphuric acid will occasion a much greater heat upon the skin when moist than when it is dry, &c.

It is therefore not sufficient that the caloric be present, it is further necessary that the body in which it is combined should have an affinity to the part we wish to cauterize, otherwise there will be no disengagement of heat.

It follows further from this tendency to union, which we regard as an indispensible condition, that when the caustic is combined or saturated with other bodies, it will have lost its causticity.

If we take an analytical review of the effects

of different caustics, and the nature of each of them, we shall find ourselves obliged to acknowledge several species; these we divide into three classes, under the denominations of *inflammatory*, *burning*, and *solvent*.

In each of the three classes, the heat is the first principle of action, it occasions the appearance of the first symptoms, such as redness, inflammation and pain, so that it ought to be regarded as the first agent of causticity. There are cases even where heat is the sole agent, and in such I use the denomination *inflammatory caustics*. For example, when we redden and inflame any part by friction simply, or when a heated body is applied to the skin, all the effects which follow depend evidently upon the free caloric which is accumulated on one point

But this heat concentrated in one part, occasions very often the combination of oxygen, in which case there is a combustion: this takes place when a burning coal, or other heated body, is held too long in contact with the skin. In this instance the application of the heated body raises the temperature of the part on which it acts, and excites redness and

inflammation, causes the fixation of oxygen, and burns the flesh. But in order that combustion may take place, it is not always necessary to derive the principle of it from the atmosphere. The caloric and the oxygen may be united in the same body; which is found to be the case with respect to the lunar caustic and the oxygenized muriates of the metals. Here the oxygen, much concentrated and slightly adhering to its bases, transfers itself to the animal substances, and burns the part to which it is applied. We see, in this case, the silver revive, and the oxygenized muriatic acid pass in the state of common muriatic acid.

The effect, therefore, of these caustics is a genuine combustion, and I call them *burning caustics*. It is easy to conceive that we can employ for this purpose those metallic salts only whose acids are easily decomposed, and that even in the class of salts formed by these acids, we cannot expect causticity, except in those in which the oxygen adheres feebly to the metal; for when the affinity is very strong the detachment is difficult, and the combustion cannot therefore take place.

The third class of caustics includes all those which dissolve the part to which they are applied: the alkalies belong to this kind, and we may even add to it lime. In these, as in all the other caustics, the first effect is produced by the caloric with which these bodies are charged: but the solution of the part speedily follows, and the alkali corrodes and dissolves till it be saturated; in this case a real animal soap is formed. These, therefore, we have, in reference to their effect, named *solvent caustics*.

This classification which we have established of the caustics, according to their effects, may have some influence on the choice of the physician who adopts them; when his object is only to cure a local inflammation, in order to draw the humours to one point, or to excite a centre of irritation, he may confine himself to the use of the inflammatory caustics, such as friction, or the application of any kind of heated body. If it be his intention to destroy morbid flesh, to re-excite vigour in a part become almost insensible, he must have recourse to the burning caustics. But when it is intended to corrode deeply, and penetrate

the cellular membrane, in order to abstract the humours and promote the discharge, he must resort to solution, and the use of the solvent caustics is indispensible.

I shall not here speak of cataplasms, of blisters, and the numerous class of exciting substances; for, exclusive of the nature of these agents being imperfectly understood, their effect seems too closely connected with the vital principle for us to attribute it to physical causes. This is so much the case, that their effect is not the same upon all animals, some of which remain unaffected by it, while the action of the caustics of which we have been speaking, is constant, necessary, and *almost* purely chemical: I say *almost*; for the vital principle still modifies the effects, and makes them much more decided. The sensibility and irritability which are heightened by their means, induce a flow of the humours, inflammation, and all the consequent symptoms. Heat when applied in the same degree to the body, produces little or no effect; and heat being the first principle of action in the effects of the caustics, we must conclude that the vital power excited by them contributes to render them energetic.

SECTION II.

Of the metallic Substances.

The metals have several characteristics which distinguish them from all other mineral substances. They are the heaviest bodies in nature; they possess a peculiar and unalterable brilliancy, which is called *metallic lustre (facies metallica)*, and they are completely opaque.

By mentioning in succession the leading properties of metallic substances, we shall make known in a more particular manner their distinctive properties, and the rank they occupy in the mineral kingdom.

I. SPECIFIC GRAVITY. The specific gravity of barytes, the heaviest earth which is known, is 4.5 with respect to pure water; while that of tin, which is one of the lightest metals, is 7.3.

It is this extreme density which renders metals malleable, and which joined with opacity, enables them to reflect that vivid copious light which constitutes metallic lustre, and

gives them the properties adapted for mirrors, unattended with the inconvenience of giving two images, as is the case with crystal.

The principal metals, compared by their specific gravity, present themselves in the following order :

Platina.
Gold.
Mercury.
Lead.
Silver.
Copper.
Iron.
Tin.

II. Colour.—M. Haüy observes, with much reason, that colour, which in most substances depends upon a foreign principle, is, in the metals, the effect of the reflection of light from their peculiar particles, whence it follows that a pure metal has always the same colour, and that this colour is the more unalterable, because it forms, so to speak, the essence of the metal.

The colours of the pure metals do not afford much variety : the principal are reducible to two, the white and the yellow. These two

colours present themselves only in shades in the pure metals.

The combination of the metals with sulphur, phosphorus, the acids, and particularly with oxygen, present a vast variety of colours, of which the greater number are used in the arts, which the metals furnish with a colouring principle, so much the more valuable, as, when it is developed, by the combination of oxygen, with the aid of a strong fire, there is no ground to fear it will change; and it from that time forms an indestructible colour for the manufacture of pottery, porcelain, enamel, and glass.

III. Hardness.—There are strong substances which, reduced to powder, are employed to polish the metals, a circumstance which implies a greater degree of hardness; but we know at the same time to what great extent the operation of tempering carries the hardness of steel, and how much the hardness of metals may in other instances be augmented by means of alloys. It is by these means that metallic substances are rendered sonorous, a property further augmented by the form. No other body is known in nature so sonorous as

the metals, or whose vibrations are so long protracted before they cease.

IV. Ductility.—The greater number of the metals yield to the blow of the hammer, or to the more equable pressure of the flatting mill: they become flat, and are reduced to plates of various thicknesses. This quality, which is called *ductility*, increases with heat; without the aid of which the metals crack and harden, and become incapable of receiving the form the artist may wish to give to them.

In this operation an approximation of the particles takes place, the void spaces are filled, and the mass decreases in volume.

It is this property of ductility which furnishes the means of giving all kinds of form to the metals. The works wrought in gold, silver, iron, platina and copper, are almost all founded on this principle.

By the power of the hammer or the forge, the forms are infinitely varied; while the aid of the flatting-mill is confined to working the metals into plates: flatting is the least injurious to the metals; the plates formed by it are larger, and, at the same time, of a more

uniform thickness; and this operation is in every respect extremely advantageous.

The metals, compared by their ductility, may be arranged as follows:

Gold.
Platina.
Silver.
Copper.
Iron.
Tin.
Lead.

There are a number of metals which are not ductile, and which break under the hammer. There are others which, yielding to the hammer without either extending or breaking, are wrought into thin plates by the more uniform force of the flatting-mill; such is zinc.

The tenacity of metals is not regulated by the same laws as their ductility. The tenacity of metals is measured by the resistance which a wire of the metal, without breaking, opposes to the action of a certain force which draws it at one end, while the other is fixed. Upon the tenacity of metals is founded the art of wire-drawing, to reduce them into wires more or less attenuated. In this operation the

metal is drawn with a force proportioned to the resistance, through various holes in succession, whose diameters are in a gradually diminishing progression. It is thus by degrees reduced to fine wires, possessing such suppleness that they may be employed as threads of silk, linen, or cotton, in executing embroidery, net-work, cloths, lattices, sieves, &c.

The metals, in the order of their tenacity, present themselves as follows:

Gold.
Iron.
Copper.
Platina.
Silver.
Tin.
Lead.

In their action with caloric and oxygen, the metals furnish other peculiar characters, which may serve to define their rank among mineral substances.

All metals are fusible; but they are not all so at the same degree of heat. Mercury preserves its liquid state, provided the cold do not exceed 37 degrees below zero of the centigrade

thermometer, (30 of Reaumur's); while pure platina supports, without fusing, the most violent heat of our furnaces.

The expansion in each metal is very perceptibly proportioned to the degree of heat; but, at a near approach to evaporation, a law prevails of much more rapid effect than the elevation of temperature. The degrees of expansion, within the limits of the graduation of the thermometer, correspond with the degrees of heat applied, with an exactness sufficient to authorise our considering the mercurial thermometer as of all others the most accurate. All the metals, without exception, suffer dilatation by heat. Some naturalists, as MM. Muschenbroek, Boerhaave, and Guyton-Morveau, have applied this property to the measuring high degrees of heat.

At different degrees of heat all metals are fusible; and in this state may be cast into moulds to consolidate them, and thus give to any of these substances the form we may desire.

The cooling of a metal fused in caloric, operates in the same manner as the crystallization of a salt dissolved in a liquid: in pro-

portion as the caloric is dispersed the particles approach each other; they unite first at the surface, because the cooling is there most rapid: a crust therefore is formed, under which the remainder of the metal continues still liquid; and if this crust be pierced to draw off the liquid mass, the internal surface will be found ornamented by distinct crystals, the intervals of which would have been occupied by the remainder of the metal, if the whole had been left to consolidate. A metal fused and then consolidated may therefore be regarded as an aggregate of small weakly coherent crystals, slightly connected one to the other; whence it arises that in this state the metals are very frangible, and that we restore their tenacity by hammering or by forging them, because the particles are thus brought in closer contact, and their affinities are strengthened.

Table of the Specific Gravity, Fusibility, and Hardness of the Metals:

Name of the Metals.	Hardness.	Specific Gravity.	Degrees of Fusibility.
Gold	6½	19.300	32 Wedgwood.
Platina . . .	8	23 000	170 and more, Wedg.
Silver	7	10.510	28 Wedg.
Mercury . . .		13.568	39 Fahrenheit.
Copper . . .	7½	8.870	27 Wedg.
Iron	9	7.788	158 Wedg.
Tin	6	7.299	442 Fahr.
Lead	5½	11.352	540 Fahr.
Nickel . . .	8½	9.000	150 Wedg.
Zinc	6½	7.190	700 Fahr.
Bismuth . . .	7	9.822	460 Fahr.
Antimony . .	6½	6.860	809 Fahr.
Tellurium . .		6.115	540 and upwards, Fahr.
Arsenic . . .	5	8.310	400 Fahr.
Cobalt . . .	6	8.150	130 Wedg.
Manganese . .	9	7.000	160 Wedg.
Tungsten . . .	10	17.600	170 and more, Wedg.
Molybdena . .		7.500	
Uranium . . .	6	6.440	
Titanium . . .	9		

Modern chemists have classed the metals among the combustible bodies; and, in effect, they are all susceptible of combination with oxygen, which is the agent of combustion, the *fire air* of Scheele. But their manner of action

with oxygen, presents to us most extreme dissimularities. Some burn at a temperature but little elevated, others require the violent heat of the electric spark, in order to combine by inflammation with oxygen.

It is only required to expose some of them to the air, or in water, to occasion their attraction of oxygen, and entering into union with it; while others, insensible to the action of this agent, at the temperature of the atmosphere, require the joint intervention of acids and of caloric to enter into combination.

As the more or less powerful affinity of oxygen to different metals, occasions a combustion or oxidation more or less easily and promptly, it follows, that the de-oxidation also must be effected with different degrees of facility: light, or a feeble heat only, are required to de-oxidate or *revive* certain metals; and there are others which cannot be restored to their metallic state but by difficult operations, and the aid of media calculated to seize upon the oxygen, the disengagement of which must be further facilitated by heat. Lavoisier suspected a metallic nature in the barytes, and thought it possible that this body might have a stronger affinity to oxygen

than this last has to carbon, which would, in his opinion, explain the cause of its having never been *revived.*

Chemists have divided the metals according to their ductility: they have denominated *metals,* such as possess this property, and *semi-metals,* such as are deprived of it. In the first, they have made the further distinction of *perfect metals* and *imperfect metals,* according as they are unalterable or changeable in the air.

These divisions, all resting upon slight modifications of the principal characteristics, are at present disregarded. We shall confine ourselves to a description of the characters belonging to each metal, leaving to time and the progress of science the charge of discovering divisions which may be fixed, great, and founded in nature, and not in a few unimportant peculiarities, or the theory of the moment.

I. *Of Gold.*

Colour yellow, specific gravity 19.2572.

Excepting platina, the most ductile of the metals.

Less hard than iron, platina, copper, and silver.

Less fusible than mercury, tin, lead, and silver.

This metal, according to Macquer, becomes volatile by the heat of a powerful burning lens; and according to Lavoisier, by the aid of a fire urged by a current of oxygen gas.

The regular figures of native gold are the octahedron and the trapezium; but it more commonly presents itself in irregular forms, in branches, in dendrites, filiform, in thin plates, or in grains and spangles.

The most productive gold mines are those of Mexico and Peru, in South America.

Gold is found in many other parts, but it is less abundant: several of our rivers, such as the Rhone, the Arriege, the Ceze, float along with their sands spangles of pure gold.

As gold does not unite readily with oxygen, and is little soluble in the acids, it is found almost always in the state of native or metallic gold; so that it is only necessary to amalgamate or dissolve it in mercury by trituration, and afterwards to distil the amalgam, in order to separate the mercury and to obtain the gold free of every mixture and of all combination.

Gold unites so perfectly with copper, that, according to the observation of Brisson, the specific gravity of the alloy is greater than the sum of the specific gravities of the metals forming the alloy.

This alloy possesses the further advantage of being harder than the gold itself; on which account the laws admit of an alloy of one eleventh part of copper in the work of the goldsmith.

As gold remains unaffected by fire or air, and is soluble in very few acids, it has merited the preference before all the other metals, of being made the representative sign of the value of all merchandize, and is equally entitled to a preference as a material to form vases, &c. for the table, and other costly ornaments.

Its very great ductility and extreme tenacity have occasioned it to be employed to gild wood, pastes, and metals, and also to cover some of our stuffs, or even to form a part of the web itself.

II. *Of Silver.*

Colour white, specific gravity 10.4743.

It is the most ductile, after gold and platina.

Less hard than iron, platina, or copper.

The forms of its crystals are the cube and the octahedron; it is also found filiform, in plates, granular, and in dendrites, &c.

When melted silver is suffered to cool very slowly, it forms into dendrites, composed of small octahedrons implanted one in the other, the assemblage of which resembles a pyramid.

Silver is, next to gold and platina, the most unalterable of the metals. The air does not change its colour, except by a long exposure; but if it be subjected to a strong heat, it at length calcines, and becomes covered with an olive-coloured vitreous scale. *See Macquer and Lavoisier.*

Silver is very readily affected by sulphurous vapours or exhalations: sulphuretted hydrogen gas quickly changes its colour, and transforms it in a short time into a sulphuret of silver.

This metal, alloyed with gold or copper, preserves its white lustre.

Silver mines are more common than those of gold.

It is often found native, but oftener alloyed with other metals; such, for example, as lead, copper, antimony, arsenic, &c.

It is also found combined and as if dissolved by sulphur, or the muriatic acid.

The methods of extracting silver from its ores, vary according to the state in which they contain it.

When silver is in a native state, it is only requisite to separate the earthy matter by trituration and washing with water, and to fuse it with lead, in order to extract all the metal. The lead is next, by calcination, converted into litharge; the litharge is removed as it rises to the surface of the melted lead, and the silver remains alone, and pure.

When silver is alloyed with copper, 75 pounds of the copper are brought into fusion with 275 pounds of lead: this alloy is cast into what are called *alligation loaves*. These loaves are afterwards exposed to a heat sufficient to melt the lead, which carries off the silver with it; the copper remains porous, and pierced by the vacancies left by the metals which have

been separated. The lead is afterwards treated in the cupelling furnace, in the manner already described, to detach from it the silver.

When silver is mineralized by sulphur or by arsenic, the ore is roasted, then stamped or pounded, and washed in water, to separate stony or earthy matters which, being lighter than the metal, are carried off by the water; the residue is afterwards melted with lead.

The properties of silver which we have enumerated, give it a rank next to that of gold; and on the same account it has been adopted as a circulating medium, and made one of the first articles of luxury in our furniture and our dress, &c.

III. *Of Mercury.*

Mercury has a very brilliant white colour.

Its specific gravity is 13.581.

It preserves its fluidity to the 32d degree below the zero of Reaumur's thermometer, corresponding to the 40th degree of the centigrade.

Mercury, at the moment of congelation, con-

tracts suddenly, so as to form a ball in the tube, the space of which it had before filled. The artificial cold produced by a mixture of snow with muriate of soda and nitric acid, easily effects this congelation.

As mercury is the heaviest of all fluids of which we have any knowledge, and does not congeal at the temperature of our climate, it has been preferred before all others as a measure of the weight of the atmosphere, which is ascertained by the height at which this metal is supported in a tube in which a vacuum has been made.

It is also employed in preference to all other fluids, in the construction of the thermometer, because its expansions from zero to the boiling point of water, appear equal or correspondent to the degrees of heat.

The ores of mercury present this metal to us in different states of combination.

1. According to M. Deborn, it is found amalgamated with silver in the Palatinate and in Upper Hungary; and according to M. Wallerius, at Salberg in Sweden.

2. The state in which mercury is most commonly found, is that of combination with sul-

phur. It then forms what is called *native cinnabar*. This mineral is of a more or less vivid red, which developes itself, and increases in intensity by levigation. Its specific gravity is from 6,9022 to 10,2185. It divides in the direction of the planes of a regular hexaedral prism, which appears to be its primitive form.

The sulphuret of mercury is sometimes mixed with bitumen: the ore of Idria is an example of this: in this case the colour is black, and the ore of less specific gravity.

3. Mercury is also found combined with muriatic acid, in the mines of the duchy of Deux-Ponts: it is called *mild native mercury*, *mercurial horn*, &c. It is pearl-grey, frangible, and easily sectile; it is totally evaporated by the blow-pipe: this last character distinguishes it from muriate of silver, which is revived by the blow-pipe.

As mercury is volatilized with moderate facility, distillation is resorted to in order to extract it from its ores; but when the operation is carried on in close vessels, it is necessary to mix stamped or pounded chalk with the ore, to promote the separation of the sulphur by supplying it with a base.

At Almaden a furnace is used, in which the ore is placed, and to which heat is applied from below the grate. The mercury, as it sublimes, escapes by twelve outlets made at the top of the furnace: to each opening is fixed a row of subliming-pots, ranged on a bank of earth, and terminating in a small building, from which rises a very high chimney. It is in the subliming-pots, and in an excavation made in the middle of each small chamber, that the mercury is found: the sulphureous gas and the air of the combustion, after having traversed these spaces, escape into the atmosphere.

The facility with which mercury forms an alloy or amalgam with gold or tin, renders it a convenient means of applying the former of these metals upon copper which is designed to be gilt; for as soon as the amalgam is applied, it is only requisite to dissipate the mercury by the application of heat, and the gold adheres to the whole surface of the metal, and a polish is afterwards given by burnishing it. Its amalgamation with tin furnishes a method of applying and fixing a very thin coating of these two metals upon the surface of crystal-glass, in such a manner as to reflect the light:

in this manner are made our looking-glasses, mirrors, &c.

IV. *Of Lead.*

Colour a livid grey.

Specific gravity 11,3525.

Among the metals which we use, lead is one of the least ductile, the least hard, the least tenacious, and the most fusible.

It crystallizes, in congealing, in small octahedrons, studded into each other.

The ores of lead are very common, and the metal is found in them in very different states.

1. *Sulphuret of Lead,* or *Galena.*

Galena is generally of a grey colour. Its gravity is from 6 to 8: its primitive form is the cube, but the most usual is that of the tetrahedral pyramid: it has little consistence, and is broken into fragments by the least shock.

Galena is also found in laminæ, or in grains. Frequently the fracture presents only brilliant faces, and the laminæ or plates may be separated from each other with great facility.

Galena is rarely exempt from alloy. Silver is almost inseparable from it, and antimony and iron are sometimes found in it.

The greater part of lead-mines are worked to obtain the silver contained in them, which constitutes their principal riches.

2. *Lead and Metallic Oxides.*

Oxide of arsenic, and the acid oxides of chrome and molybdene, are sometimes united with lead in the ore.

The ores of lead which contain arsenic, are of a yellow or greenish colour, easy to reduce, diffusing, when heated, a smell of garlic.

Those in which the lead is combined with the acid of chrome, are of a red colour mixed with an orange tinge, easy to scrape with a knife, and they crystallize in rectangular prisms with a square base, divisible parallel to the planes which would pass through the diagonals of the bases. M. Vauquelin extracted from them 63,96 of oxide of lead, and 36,40 of acid oxide of chrome. This state of lead was described under the name of *red-lead*, before its constituent principles were known.

3. *Lead and Acids.*

Lead is frequently combined with acids, as the molybdic, the carbonic, the sulphuric, the phosphoric, the muriatic, &c.

The ore in which lead is united with the molybdic acid, is yellow, divisible into octahedrons, tender, fragile, and decrepitating when exposed to heat. When analysed, it is found to contain 28,00 of molybdic acid.

Carbonate of lead dissolves without effervescence in nitric acid. Its gravity is from 6,0717 to 6,5585. It is tender and fragile, and in colour of a dead white. Its primitive form is that of a rectangular octahedron. It is that which mineralogists have hitherto called *white ore of lead.*

M. Westrumb found in it carbonic acid, in the proportion of 16,00.

Carbonate is sometimes disseminated in the interior of various earthy matters differently coloured. It was from the colours that the ore has been called *minium*, *massicot*, or *ceruse*, according as it was red, yellow, or white.

The phosphoric acid in which lead is dis-

solved, forms a *phosphate of lead* which is found in many mines.

The colour of this phosphate is an opaque white, sometimes green, gray, or reddish. It gives with the blow-pipe a polyhedral button. Its specific gravity is from 6,909 to 6,9411. Its primitive form is that of a bi-pyramidal dodecahedron. It contains 18.75 parts of phosphoric acid out of 100, according to M. Klaproth. M. Fourcroy found only 14,00 in that which he analyzed.

What is called black-lead, is only phosphate of lead which has passed, wholly or in part, into the state of sulphuret of lead.

Sulphate of lead is tender, and may be crushed under the finger: its primitive form is the octahedron.

It may be melted by the flame of a wax candle, and is not dissolved by the nitric acid.

Its colour is limpid or yellowish.

Almost all the mines of lead which are worked are in the state of sulphuret, and the manner of working them varies very little. The different operations consist, 1. In picking the mineral to separate the unctuous, rich, or pure

ore, and the stony matrix, and other impurities; 2. In pounding the picked ore under the stampers; 3. In washing the pulverized ore, to carry off the *gangue* or matrix by the water; 4. In roasting the mineral in a reverberatory furnace, taking care to stir it to facilitate the evaporation of the sulphur. When the surface begins to become of the consistence of paste, it is covered with charcoal; the mixture is shaken, the fire increased, and the lead then flows down on all sides to the bottom of the basin of the furnace, whence it is drawn off into moulds or boxes adapted to receive it.

The scoriæ which still retain much lead, are melted in a smaller furnace.

Lead is the softer the more it is pure. The alloy of a small quantity of silver or copper renders it brittle, and diminishes its quality. The silver is separated from it by cupellation, but the copper remains, as does iron, when these metals are found mixed with it in the mine. The lead is then brittle, and only of use to make small shot. The minium and litharge that are made from it, render crystal of a brownish colour, and cannot be usefully employed in the composition of glass or mock-crystal.

Lead alloyed with a little arsenic is very brittle: this is the alloy employed in the making of small shot. The lead is melted with a little arsenic, and when the mixture is at that degree of heat that a card may be plunged into it without taking fire, it is poured into a vessel full of burning coals, and pierced with holes; this is held over another vessel filled with water, into which the lead falls in the form of shot. By making the melted mixture fall from a very great height, the lead will reach the ground in the form of shot. The shot is then sorted according to the different sizes, by passing it through sieves, the holes of which are of different calibres, and so placed that those with the largest holes are uppermost.

The ductility of lead renders it easy to be run or to be flattened, to form it into sheets of large dimensions. It is run on sand or in a mould, and by means of a kind of rake, the thickness that may be desired is given to it.

The laminating rollers or flatting-mill, produce the same effect, and have the advantage of rendering the lead more compact.

These sheets of lead are used to cover the roofs of houses, terraces, &c. and to make

vessels for the evaporation of various salts, certain acids, &c.

V. *Of Copper.*

This metal is of a reddish yellow.

Its density is less than that of platina, gold, mercury, or silver. Its specific gravity is 8,5844.

It is less hard than steel and platina; but harder than silver, gold, tin, and lead.

Its ductility is less than that of gold, platina, and silver; but greater than that of iron, tin, and lead.

Next to gold and iron, copper possesses the strongest tenacity: it is more sonorous than any of the known metals.

The primitive form of native copper is the cube: frequently its form is confused, indeterminable; and it then presents itself in branches, filaments, plates, or grains.

Besides native copper, which is found abundantly in several mines, this metal exists in a state of combination with sulphur; sometimes in the simple state of a pure sulphuret, and

sometimes in the state of a mixed sulphuret of iron, copper, antimony, or arsenic. It is also found combined with different acids, as the carbonic, muriatic, sulphuric, &c.

1. *Sulphuret of Copper.*

This ore is of a grey iron colour in its natural state, or when rubbed with a hard body: its specific gravity is 4,81, according to M. Deborn.

This sulphuret is fragile and tender, capable of being scratched with the knife: it is rarely exempt from a little iron, which causes the button or globule obtained by the blow-pipe to act on the magnetic needle.

It emits the odour of sulphureous acid by calcination; and forms a solution of a blue colour with mercury.

This is the ore of grey vitreous copper of Daubenton.

Klaproth obtained from the sulphure of copper which he analyzed 18,50 of sulphur, 78,50 of copper, 2,25 of iron, and 0,75 of silex.

2. *Sulphuret of copper mixed with other metals.*

When the sulphuret contains only iron in no very considerable proportion, the result is a yellow ore, not malleable, of a specific gravity of about 4,3134, the crystals of which approach the regular tetrahedron, and which is known in mineralogy by the names *pyrites of copper, yellow ore of copper*, &c. This ore is the most common. It is found in veins of more or less extent, or in masses. The colour varies according to the proportions of the three principles of which it is constituted: when the quantity of iron and sulphur in it is small, the colour is a blueish violet. A specimen of this latter species afforded M. Klaproth 63,7 of copper, 12,7 of iron, 19,0 of sulphur, and 4,6 of oxygen.

The sulphuret of copper is sometimes alloyed with iron and arsenic; there are even ores in which lead, antimony and silver, are also united to the former metals, and these native alloys present a mineral of the grey colour of steel, easy to break, the primitive form of which is the regular tetrahedron, and the spe-

cific gravity 4,8648. This ore is that which has been called *grey ore of copper*, *grey ore of silver*, *antimonial ore of copper*, according as one or other of these metals predominated.

Sometimes arsenic exists in the state of acid with copper: the mineral then is of a grass-green or olive-green colour, tender, and easy to bruise or pound.

M. Vauquelin, who analyzed a lamellated formed arseniate of copper, found in it—

43 of arsenical acid.
39 oxide of copper.
17 water.

M. Lelievre was the first who made us acquainted with this substance and the nature of its principles.

3. *Copper and Acids.*

The acids with which copper is found in a state of combination are the muriatic, the carbonic, the sulphuric, &c.

The muriatic acid mineralizes the copper in

the *green sand* of Peru. The mineral has then the green colour of an emerald, and colours green and blue the flame of our common fires. It dissolves without effervescence in nitric acid.

What is called *azure of copper*, or mountain blue, and *malachites*, or mountain green, is only a carbonate of copper.

Azure of copper is of the blue colour of azure or lapis lazuli: it dissolves with effervescence in the nitric acid. Its specific gravity is 3,6022. It is easily scratched with a hard body. The primitive form is that of the octahedron with scalene triangles. It is easily fused with the blow-pipe.

The colour of turquoises has been generally attributed to the oxide of copper; but M. Bouillon-Lagrange has demonstrated that these coloured bones do not contain an atom of it, and his inquiries have proved that 100 parts of turquois contain—

Phosphate of lime . . .	80
Carbonate of lime . . .	8
Phosphate of iron . . .	2
Phosphate of magnesia .	2

Alumine	$1\frac{1}{2}$
Water and loss	$6\frac{1}{2}$

The name of *Armenian stone* is given sometimes to a quartz tinged with a blue colour by the azure of copper, and sometimes to a calcareous stone coloured by the same substance. Turquoises and Armenian stones present almost always a mixture of green and blue colours.

Malachite is of the most beautiful green colour. Its specific gravity is 3,5718. It may be easily scratched with a knife. It dissolves with effervescence in the nitric acid, and colours the flame of it green.

Pelletier found more oxygen in this carbonate than in the blue, and this, according to him, is the only difference there is between them.

Malachite is susceptible of the finest polish, and as it is found in masses or stalagmites, of it are made cups, snuff-boxes, or trinkets, which are pleasing to the eye, as the surface is almost always ornamented with zones of various strongly marked colours, with succession of the beds or layers that have gradually formed the malachite.

Sulphate of copper is sometimes formed by the decomposition, or rather the efflorescence of the sulphurets of copper: but this salt can, on that account, only be found on the surface of the earth, or in cavities accessible to the air. Water carries it off almost as fast as it is formed, and it contracts very deleterious qualities from the solution of this salt. There are waters which contain it in sufficient quantities to permit the copper to be extracted with advantage. Copper in this state is called by the French workmen, copper of cementation.

The mines of sulphureous copper are almost the only ones that are worked. Though the processes vary, they agree generally in the following operations.

The mineral is first picked to separate the fat or rich from the meagre ore; and that which contains much of the stoney matrix is pounded, and afterwards washed, to separate the gangue, which the water carries away, in preference to the mineral, which is heavier. The ore is then roasted to carry off the sulphur, after which it is melted in the furnace. This first melting gives what is called black copper, which is again melted in the refining

furnace, and kept in fusion for a considerable time, in contact with charcoal, to disengage the last portions of sulphur, which strongly adhere to it. When the copper is thus rendered very pure, it is made to flow into the receiver, and a little water poured upon the bath, to hasten its cooling, and form a bed or layer, which is taken away. By repeating this operation, all the copper which is in the receiver is converted into leaves or plates of copper, which are subjected to the hammer, to give them the requisite form, thickness, and polish.

There are places in which the copper is made to undergo eight successive roastings, which depends especially on the nature of the ore. When that abounds in sulphur, this mineralizer may in a great measure be extracted, by forming large beds of ore on a mass of combustibles, and closing the sides with clay, nearly in the same manner as in the operation of making charcoal. The heat of the burning combustibles sublimes the sulphur, which flies off, and collects in hollows or cups formed in the ore, on the flat surface of the upper part See the *Voyages Metallurgiques* of M. Jars.

In some mines in England, the ore is roasted and melted in the reverbatory furnace.

The hardness of copper, and its ductility, have multiplied its uses. It is the material of almost all the vessels used in our laboratories for evaporation, solution, crystallization, &c. The greater part of our domestic operations are performed in vessels of this metal. It has been believed that the use of them was dangerous, because the aliments prepared in them might acquire noxious qualities, by taking up some metallic atoms; but the late experiments of M. Proust have banished these fears, provided we do not leave in the vessels of this metal acid mixtures, or stale eatables, and take care to clean them well. Cleanliness is afterwards sufficient to preserve from every accident.

The coppering of the bottoms of ships occasions at present a great consumption of copper. This practice facilitates the progress of the vessel through the water by presenting a smoother surface, and not permitting shell-fish to fasten to it, as they do to wood. It likewise preserves the ship's bottom from the puncture of worms, and consequently secures to it a longer duration.

The tenacity of copper permits it to be drawn into wire, which is of very great use in the arts.

VI. *Iron.*

Iron is the most widely diffused of the metals, as it is also the most valuable, from the very numerous uses to which it is applied.

This metal is of a grey colour, with blueish shades.

Its specific gravity is 7,788, and its hardness superior to that of other metals.

Next to gold it holds the first rank with respect to tenacity.

Though it has been affirmed that native iron has been found in various places, and that naturalists worthy of confidence have given a description of it, the existence of this metal in a native state is not yet generally admitted nor well established. M. Guyton-Morveau even denies the possibility of it, because iron is never really ductile till it has passed under the hammer; and because there is not any

solution, either humid or dry, which can supply the place of that operation. We are therefore inclined to believe, that the masses of native iron, of which we have heard, owe their origin either to the labour of man, or to subterranean fires.

The ores of iron present to us combinations with oxygen, sulphur, metals, and acids, nearly in the same manner as other metallic substances.

M. Hauy observes, that the ores in which the iron contains the least oxygen without being engaged in other combinations, form natural magnets; and he calls the loadstones of commerce, which are found in considerable masses in Sweden, Norway, China, Siam, the Philippine Isles, Corsica, &c. *oxidulated iron.*

The loadstone is characterised by the following properties.

A very strong action on the magnetic needle.

Specific gravity 4,2457.

Not ductile.

Of a dark grey colour, with a metallic lustre.

Primitive form the regular octahedron.

Insoluble in the nitric acid.

The ore of iron, which has been successively called *ore of specular iron, specular iron of the volcanoes*, &c. contains a much greater quantity of oxygen, and is much less strongly attracted by the magnet. Its specific gravity is 5,0116; its colour the grey colour of steel; its primitive form a rhomboid, somewhat acute.

The most celebrated mines productive of this species are those of the Isle of Elba, and those of Framont, in the department of Vosges. Our collections of natural history present numerous specimens of these ores, equally curious from the liveliness of their colours and the variety of their forms.

The mines of Mont d'Or, Puy de Dome, and Volvie, likewise afford specular iron.

The ores which only present iron in a state of simple combination with oxygen, are treated with success by the method called the *Catalonian method.* In this it is only necessary to melt the ore and place it in contact with charcoal, to furnish a base to the oxygen; whereas, in the treatment of alluvial ores, it is necessary, after having effected the fusion,

to proceed to refining, to obtain malleable iron.

Sulphur is frequently the mineralizer of iron in the ores. These natural sulphurets are known by naturalists by the names of *martial pyrites*, *marcasites*, &c. Their colour is generally the yellow colour of bronze. The forms approach to that of the cube, or regular octahedron. The specific gravity is 4,1006. Their hardness is such that the pyrites emits sparks when struck against steel.

Martial pyrites are often found under the form of round bodies, the surface of which is rugged, and full of small trihedral pyramids, opposed at their base to other pyramids of the same form, which extend and terminate in a point at one common centre.

Martial pyrites is also frequently found dispersed, sometimes in schistus, sometimes in clay, sometimes in bitumens, and sometimes in woods decomposed and in the state of jet.

It sometimes happens that the sulphur disengages itself from this sulphuret, which then loses its metallic brilliancy and assumes a blackish colour. In this state it is called *ore of hepatic iron*. But when the iron, thus

disengaged from its mineralizer, is reduced to the state of a very fine metallic dust, the waters carry it off, and deposit it in beds, or stalactites, which are called hæmatites. It is to a similar cause that we may refer the formation of those beds of ochre, so common on the surface of the globe, with only this difference, that the decomposition of the sulphuret is here complete, and that the iron is more strongly oxidated.

Martial pyrites are extremely abundant among the bodies that compose our globe. It even appears that in its primitive composition they formed more numerous beds; but as the contact of air or water, assisted by a little heat, occasions the decomposition of the pyrites, they must have successively effloresced, and produced different results, according to their nature and mixture. When the pyrites contains bitumen, its decomposition often produces combustion. This is frequently seen in mines of pit-coal, where the coal is very pyritous. If a heap of it be left in the mine, or at the neck of the galleries, it will become hot and take fire. The result is almost always a reddish residue, furnishing alum and sulphate

of iron when analyzed. Sometimes the combustion takes place even in the vein of a mine of bad pit-coal: and then are produced all the phenomena attendant on volcanoes; they are only modified by the very variable quantity of the matter in this state of decomposition, and by the resistance which the developement and free issue of the gases that are formed may encounter. Those long and numerous traces of volcanoes, which we meet with at every step on the surface of the globe, appear to me to have had no other origin. The volcanic residues, which, by the resistance they make to fusion, give us reason to believe that at their formation they experienced a very violent heat, may have been brought into a state of imperfect fusion by means of sulphur, which being once evaporated, leaves residues almost infusible; as we see platina, rendered extremely fusible by being mixed with arsenic, resume its infusibility as soon as the arsenic has been driven out of it by heat.

When the pyrites contain only sulphur and iron, its decomposition affords sulphate and ochre: the sulphate is carried off by water, and the ochre remains yellow, brown, or red-

dish, according to its degree of oxidation. Ochre is frequently found in beds, and more frequently scattered in different places. It may be brought to a lively bright red colour by calcination, and it then becomes what is called *red brown*.

If the pyrites is mixed with earthy principles and other metallic substances, sulphates of alumine, of lime, of iron, of copper, of magnesia, &c. are produced, which being differently soluble in water, are carried off and deposited in strata and belts. It is to this cause, productive of so many phenomena, to this great agent of motion, composition, and decomposition, in a word to the efflorescence and action of masses of pyrites, that we must attribute the greatest changes that have taken place in our globe.

Iron is likewise found combined with carbon, and then forms what is called *plumbago, carburet of iron*.

This mineral marks paper with a grey metallic lead colour.

Its specific gravity is 2,0891.

It is easily cut, and its surface is unctuous.

It affords 90,9 of carbon to 9,1 of iron.

It is found in small plates of the whiteness of tin, which appear to approach the figure of a regular hexagon. It is sometimes found in grains. Very frequently this carburet is implanted in argillaceous beds, in knots or clods, on which account it was called by the ancients *glebæ plumbariæ*.

Of plumbago, or black lead, are made the pencils that bear that name, and which are manufactured in England, in the county of Cumberland, where this mineral abounds. They are made by sawing the mineral into long and thin pieces, which are inserted in a groove made in a half-cylinder of wood, to which another half-cylinder is fitted, in such a manner that it may slide over it and uncover a part of the pencil. In pencils of a lower price, the two half-cylinders are glued together. Pencils of a lower price still are made with the dust or powder of plumbago, to which a consistence is given by mixing it with gum or melted sulphur. This powder is likewise used in the making of excellent crucibles, by kneading it with clay.

Plumbago is also used to preserve from rust stoves, and other utensils of iron, for which

purpose it is only necessary to rub them with it occasionally.

It is likewise mixed with grease, and used to lessen the friction of pieces of metal employed in the construction of wheel-machines.

We have already spoken of oxides of iron, when treating of the decomposition of sulphurets; but we cannot omit saying a word of an oxide of iron, mixed with quartz, with which is formed a combination sufficiently hard to scratch all bodies except the diamond. This is what is called *red emery*. Its specific gravity is 4,0. Its fracture is in fine and close grains.

Emery is not worked as an ore of iron, but is used to polish stones, glass, and the hardest metals: for this purpose it is prepared in the following manner.

It is ground in steel mills, and afterwards separated, according to its several degrees of fineness, by washing it in water, and suffering the grosser particles to deposit themselves, in order to preserve only the finer, which remain suspended, and which are obtained by decanting the water off, after having let it stand for a considerable time. The particles first deposited are then ground again, and again agitated

in the water to separate the finest. By these successive operations, the emery is reduced to an impalpable powder. In general, only those particles of emery which remain suspended in the water after standing about half an hour, are used to polish metals.

Iron is likewise found united with arsenic in the bowels of the earth, and it is then called *ore of white arsenic, mispickel, pyritous arsenic, arsenical pyrites*, &c.

This mineral is of the white colour of tin: it strikes fire with steel, and exhales a smell of garlick. Its specific gravity is 6,5223. Its primitive form is a straight rhomboidal prism.

Arsenical iron sometimes contains silver. M. Klaproth found 12,75 parts of silver in the ore of Andreasberg.

One of the most widely diffused natural combinations of iron, is that which constitutes the ore of sparry iron. Bayen found in it the carbonic acid united to iron: Bergmann found the carbonate of lime and oxide of manganese. M. Drappier has proved, that the carbonate of lime was only in it accidentally: he found only a little manganese, but much magnesia. M. Descotils confirmed the existence of magnesia,

and extracted 0,125 of it. M. Drappier had obtained 0,145. M. Descotils observes, that it is the ores which crystallize in large plates that afford magnesia. The resemblance of the forms which sparry iron has to the carbonates of lime, has not only procured it the denomination of *sparry*, which has been given to it from the term *calcareous spar*, but appears to have contributed to support the opinion, at present disproved by experience, that it was only a carbonate of lime.

In general, this ore is easy to treat, and affords an iron of a good quality. It is melted in the furnace after the Catalonian method, and steel is frequently extracted by a first fusion; but when the mineral contains much magnesia, it is considerably more difficult to melt than when it contains but little. In the former case it is exposed to the air and the rain, because the carbonate of magnesia, which has some solubility, is dissolved and carried away by the water; and this effect is assisted by the carbonic acid, which the iron abandons in taking up more oxygen. M. Descotils has proved, that the greater or less fusibility of sparry iron depends on the proportion of the

magnesia contained in it, while that of the manganese is indifferent. This latter substance has no influence but on the metal which is produced from it, as Stangel has observed.

Iron is also found dissolved in different acids, as the prussic, the sulphuric, the chromic, &c.

The prussiate of iron, known likewise by the names *native prussian blue*, *blue martial ochre*, &c. is of a pure blue colour, more or less deep. It becomes black in oil, and with the blow-pipe gives a scoria of a blackish brown, which is attracted by the magnet.

The sulphate of iron, *green vitriol*, *green copperas*, is produced by the decomposition of sulphurets of iron. We shall speak of this salt much more at length hereafter.

Chromate of iron has been found in the department of Var. It is of a blackish brown colour, with a slight metallic brilliancy.

The specific gravity is 4,0326. It is infusible without addition, scratches glass, and breaks under the hammer.

It afforded M. Vauquelin—

45.0 chromic acid.
34.7 oxide of iron.
20.3 alumine.
2.0 silex.

Iron exists almost every where; but the denomination of *iron ore* is only given to that mass of mineral in which iron is sufficiently abundant to admit of being worked with advantage. The mines of spathic iron, of oxides of iron, forming hæmatites, beds of ochre, specular iron, or alluvial ores, are those which are commonly worked.

The manner of working iron mines varies according to the purity of the ore, the state in which the iron is found in it, and the nature of the substances which are mixed with it. When the iron exists in a state approaching the native state, and contains no matters which diminish its capability of fusion, or mix with it when in fusion, it is sufficient to melt the ore by placing it in contact with charcoal, to obtain iron. The method employed in this case is called the *Catalonian method*, and is used especially for those ores of sparry iron in which magnesia is not very abundant; for ores in stalactites or hæmatites, in which the oxide of iron is almost pure, and combined with but little oxygen; for ores of specular iron, free from gangue, and every mixture of foreign substance. These ores afford pretty generally more or less steel at a first fusion.

The alluvial ores, and in general all those which are loaded with earthy substance, or some metallic matter, require a more complicated labour, and the fusion is performed in what are called the *high furnaces*. The interior of these furnaces presents two four-sided pyramids joined at their base. The combustible matter is introduced at the upper part, and, when it is well ignited, the ore is thrown in, which passing through this bed of charcoal, becomes heated, separates from its mineralizer, softens, and flows, in proportion as it approaches the base, where the heat is infinitely more strong, because there are the orifices of the bellows by which the fire is excited.

When the ore is argillaceous, or is mixed with calcareous stone, which is called by the French workmen *castine*, clay, denominated *herbue*, is mixed with it. The addition of these foreign matters facilitates the fusion.

As the metal becomes fused, it flows down, and collects at the bottom of the furnace; whence it is drawn off from time to time, into moulds prepared to receive it, and give it the desired form.

This first state of iron is called cast-iron:

it is very hard and brittle. Of it are made chimney-backs, cauldrons, pots, pipes, and an infinity of utensils and vessels, useful in the arts, and for domestic purposes. By taking care that the melted metal is pure and very liquid, it may be made to assume the most exact forms; so that many utensils, and other things of various kinds, which were formerly only made of ductile and malleated iron, are now made of cast-iron.

In this state the iron is mixed with a remainder of oxygen and a little carbon, and sometimes also with some earthy or metallic particles, from which it is freed by further operations. For this purpose the cast-iron is melted, and care is taken to knead and stir it, that all its parts may be presented to the air, and the extraneous matters brought to the surface. By degrees the iron becomes ductile, and is then formed under the hammer into square or flat bars of different sizes, for the purposes of commerce.

Hammering contributes greatly to ameliorate iron. This operation is called *forging*. By it, it is not only deprived of the carbon and the little oxygen which might remain, but all the

parts are brought together, united, and made to assume cohesion; and thus the iron becomes more ductile, more flexible, more tenacious, and of a more equal quality.

Iron by being well forged, is also rendered of an equal quality in all its parts. Without this operation, we should find bars of iron brittle at one end, ductile in the middle, and fragile at the other extremity; and it is this inequality in the same iron which has hitherto presented almost insurmountable difficulties to the success of our manufactures of steel, and of tools or utensils made of iron, to which the artist gives the quality of steel in his own workshop

To form an accurate idea of the labour necessary to be performed on the ores of iron, and the products obtained from them, we must consider the ores of iron as mixtures of iron and oxygen, or of iron and different foreign matters, which are combined or alloyed with it in different proportions.

In the first case it is sufficient to present the ore to the ignited charcoal to disengage the oxygen, and leave the iron in a free state. The working of these ores is simple and easy: it

almost constantly affords iron of an excellent quality. It frequently happens that a part of the metal is converted into steel, because the melted iron being in contact with the charcoal, combines with it in sufficient quantity to be transformed into steel.

But when the iron is mixed with different foreign matters, whether earthy or metallic, the melted mixture is in part alloyed with these substances. The strong degree of heat which is necessary to effect a proper fusion, contributes to mix with it more or less carbon. The oxygen itself is either disengaged with difficulty, or combines anew, by the continued action of the bellows. A part only of the extraneous matters being softened, fused, and lighter than the iron, collects on the surface of the metallic bath, where it forms a vitreous scoria denominated *scum;* so that the melted matter contains oxygen, carbon, and more or less of the foreign substances which are found in the ore with the iron. The existence in it of all these bodies, has been demonstrated by the scientific analysis given us by MM. Monges, Berthollet, and Vandermonde.

The melted mixture is white, grey, or black,

according to the proportions in which these principles are contained in it. The white contains less carbon than the grey. The operation of refining, used to deprive iron of all these foreign matters, and give it that ductility which characterises it, is entirely founded on these principles; and it is sufficient to know, that when the melting abounds in carbon, it must be stirred, and presented to the air and the current of the bellows, to disengage it; whereas when it contains considerably too much oxygen, it is necessary to knead it with charcoal to take up the oxygen. Heat alone is sufficient when the carbon and oxygen are contained in it in suitable proportions, because then they volatilize together in the state of carbonic acid.

It will now be conceived how requisite it is to purge the iron from all these principles, to give it its utmost ductility; but it may be observed at the same time, how easily the proper limits may be passed; in which case another change must be made in the metal, to restore to it the properties it has lost.

To give to iron all the qualities it ought to possess, after having separated from it by fu-

sion, the earthy parts and lighter metals, which are brought to the surface in the form of scum, it must be forged, and worked with the hammer with the greatest care. Besides that, by this means, the particles of iron are brought into closer contact, the remainder of the impurities it might contain are expelled, and a tenacity is given to it which it never could acquire without the aid of the hammer.

Independently of the extraneous matter of which we have spoken, and which may be separated in the melting by the known processes, there is frequently found a phosphate of iron which resists all these operations. It is this phosphate which renders iron what is termed *cold-short* and *hot-short*. The iron which has this bad quality is brittle, and usually has a coarser grain than the soft iron. We are indebted to Bergmann for the discovery of this phosphate. He separated it by dissolving the iron in the sulphuric acid; for it precipitates in the solution under the form of a white powder, which has been called *siderite*, and which Bergmann took at first for a new metal; but Meyer of Stettin has proved that it is a true phosphate. To obtain this phosphate, the solution

must be saturated by a gentle heat: it then precipitates, by being left at rest, in four or five days. It may likewise be obtained by dissolving iron in the nitrous acid, and evaporation to dryness. The iron is oxidated by this first operation. More nitrous acid being poured on it, dissolves only the siderite, without touching the oxide. A second evaporation is then made, water is poured on the residue, and what remains is siderite. Siderite may be decomposed by the alkalies, and by lime.

When iron has been brought to that state of purity which gives it great ductility and much tenacity, it may, by combining it with a little carbon, be made to acquire new properties, which render it very valuable to the arts, and it is then known under the name of *steel*, or *tempered steel*, &c.

All kinds of iron are not proper to afford good steel: those which are the softest and most ductile are to be preferred. In England, where almost the whole of the steel used in Europe is made, the iron of the district of Rosalgia in Sweden, is alone made use of.

All the processes for converting iron into steel, may be reduced, with some differences

in the construction of the furnaces, to that which is practised in the vicinity of Newcastle, in England.

After having made choice of the best iron known, the bars of which are in general from an inch and a half to three inches in breadth, and about half an inch thick: these bars are cut of the length of the cases in which they are tempered. These cases, at Newcastle, are about ten feet and a half long by two feet in height, and nearly the same in breadth. Into each case of these dimensions, is put about twelve thousand pounds weight of iron; and as there are two of these cases in each furnace, the operation is performed on about twenty-four thousand pounds weight each time.

The cases are made of free stone slabs, cemented together with clay, which is introduced into the joints, and they are placed in the furnace in such a manner that the fire may act on all the surfaces. The bars of iron are thus disposed in them: A bed of charcoal-dust slightly moistened with water, is first formed at the bottom, and over it is placed a range of bars of iron laid parallel to each other, but without touching. This first range is covered

with a bed of charcoal-dust, about half an inch in thickness, and the void space between the bars is carefully filled with the same dust. Beds of charcoal and ranges of iron bars are thus successively raised one over the other, and the uppermost bed of charcoal is covered with one of moistened sand, rising in a ridge above the case.

When the cases are filled, the openings of the furnace by which they were introduced for this first operation, are closed, and the fire is kindled, which is continued during five or six days, in such a manner as to maintain all the contents of the cases at a red heat. Habit is sufficient, in many manufactories, to enable the manager of the process to judge when the tempering is complete; but, in some, a small aperture is made in the furnace, corresponding to a similar aperture in the case, and one of the bars is taken out from time to time, to judge of the state of the operation.

When it is found that the iron is totally converted into steel, the masonry of the extremities of the furnace is pulled down to accelerate the cooling, the bars of the grating are taken out to carry away the charcoal, and at the end of a week, the steel may be taken out.

In this first state the steel is called *blistered steel.*

It is forged with the hammer, and the bars of iron are reduced to a square about seven or eight lines in thickness, and of an indeterminate size; afterwards it is left to cool in the air, without dipping it in water The large facets which the blistered steel had are reduced into small grains, and in this state it is called *common steel.* It is used to make files, saws, scissars, knives, &c.

As the extremities of the bars converted into steel usually have flaws in them, and are a less perfect steel, they are cut to be forged into *packets* or parcels, and this steel is called *soft steel.* It is used by welding it to the extremities of agricultural utensils.

The valuable quality of tempered steel may likewise be increased, by taking the bars when they come out of the furnace, and forming bundles of them of ten or twelve each. These bundles are heated in charcoal, taking care to throw over them, from time to time, dry clay, to concentrate the heat; and when the bundle is very hot, they are welded, beat out, and forged. *German steel* is thus ob-

tained. It is by the same process that steel is prepared in Styria, and at Newcastle.

The English likewise give new properties to German steel, to employ it in delicate manufactures. For this purpose, to reduce their own steel into German steel, they use only wood-charcoal. They then temper this German steel in the same manner as iron, and forge it again in bundles with wood-charcoal.

Iron is capable of imbibing very various quantities of carbon. From steel, which does not contain of it, at most, more than $\frac{1}{32}$, to plumbago, which contains $\frac{96}{100}$, the intermediary proportions are very numerous. Beginning with the state of steel, which is only iron combined with a little carbon, and gradually increasing the proportion of the latter, iron will be made to pass through the state of the white melting, the grey melting, &c. till it arrives at that of plumbago. In proportion as the quantity of carbon is increased, the iron becomes more and more difficult to forge, and more easy to soften by fire. There is a certain proportion in which iron and carbon combined give a fusible and malleable steel; but this limit passed, the qualities of the steel degenerate, and it then approaches iron.

In proportion as the quantity of carbon is augmented, the fusibility of the combination is increased; the grain of the substance, which was that of steel, changes, and the fracture no longer presents one uniform substance, similar to that of the white meltings. It is brought to the state of the grey melting, at the same time that it is rendered more and more fusible by increasing the proportion of carbon.

M. Clouet has proved, that iron may be combined with a little glass, and that the substance thus produced is fusible, and a little ductile, but not capable of being forged. This mixture is brittle: it may be filed and engraved like soft iron: its fracture nearly resembles that of steel when tempered, but it has not its hardness.

If a little charcoal be added to the glass, from a twentieth to a thirtieth part, and these three substances fused together, the result will be a hard steel, which may be forged at a red-heat. This steel has all the characters of the cast steel of commerce.

It appears even that, at a high temperature, iron will take carbon from oxygen; for if we take equal parts of carbonate of lime and clay

in powder, and after having mixed them with iron in a crucible, subject them to a very violent heat, the melted matter run into a mould, will exhibit all the characters of cast steel.

VII. *Of Tin.*

The colour of this metal is white, approaching to that of silver, but a little darker.

The specific gravity is 7,2963.

It is the most fusible of ductile metals.

When it is bent different ways, it makes a cracking, called by the French the *cri d'etain.*

Mines of tin are rather rare, and those which exist differ little from each other.

The ores which are worked are all oxides of this metal, that are every where found in crystals, of which the primitive form is the cube; and the colour sometimes white, sometimes red, sometimes brown, yellow, or blackish. These crystals are sometimes translucid.

The specific gravity of the oxide of native tin is 6,9009: it sparkles when struck with the steel: its fracture is rugged.

Blackish oxidized tin has been taken for wolfram, but the latter does not give sparks with steel, and is more easily cut by the file. The sulphuret of zinc, or reddish blend, has likewise been confounded with red oxidized tin, but the former does not give sparks: it is easily divided into plates.

Tin is found alloyed with copper, and mineralized by sulphur. M. Klaproth, who analyzed a specimen of this kind, found in it:

Sulphur	25
Tin	34
Copper	36
Iron	2

In the processes for extracting the metal from the ores of tin, the ore is first carefully picked, then pounded, and washed on tables covered with cloth, while it is continually moved and stirred with a rake. By this means the gangue or matrix is carried off, and the mineral remains pure.

The furnace which is used in Saxony for melting ores of tin, is a variety of the portable furnace. A groove or channel is made at the

bottom, to receive the tin as it flows, and transmit it into the basin, whence it is taken out, to give it the form it has in commerce.

The ores of Cornwall are often mixed with copper and arsenical pyrites. The quartz, which is their matrix, is very hard, and on that account the ore is torrefied before it is pounded. When it is washed, magnets are passed over it, to take up the iron. It is melted in the reverberatory furnace, and the scoriæ of the metal are again passed through the furnace three times, to separate its last portions from them.

We are acquainted with three kinds of tin in commerce.

1. *Pure tin*, such as that of *Malacca*, of *Banca*, and the *soft tin of England*. That of Malacca is cast in moulds, which give it the form of a truncated quadrangular pyramid, with a thin turned-up edge at the base It is known in commerce by the name of *kat tin*, or *standish tin*.

2 *English tin*, in large pigs, or cast in rods or bars, of about one inch in breadth and 18 inches in length. This is most used.

3. *Plumber's tin*, is alloyed with lead, and even with a little copper and bismuth. The

law permits it to be alloyed with these two metals. The copper gives it hardness, and the bismuth restores the brilliancy of which the copper had deprived it, at the same time rendering it sonorous.

The workers in tin likewise mix with it antimony, to render it hard, and zincs to whiten it.

Bayen and Charlard have proved, that the metals prejudicial to health, as arsenic, cannot be mixed with tin, even artificially, in such a manner as to render this metal dangerous; so that we may, with the utmost confidence, continue to use it for domestic purposes. They have completely dissipated the fears, in this respect, which Margraaf had inspired, who had suffered himself to be deceived, by mistaking for arsenic what was not that metal.

Tin has great ductility under the hammer: it may be beat out in such a manner as to form leaves or plates thinner than paper. But when it is thus worked, several leaves must be joined together: they then support each other, and yield to the hammer without tearing. These leaves, which may be said to have scarcely any thickness, are used to silver glass globes, to

plate other metals, &c. Those used for silvering looking-glasses are much thicker.

VIII. *Zinc.*

The colour of zinc is a lightly blueish white.

Its specific gravity is 7,1908.

It dissolves in the nitric acid with effervescence.

It burns with a brilliant flame: the oxide which results from the combustion is white, light, flocculent, floating in the air.

This metal yields to the hammer without breaking. It cannot be properly ground or pounded but when it is very hot. It is reduced into thin and very flexible plates, by the more equal pressure of the laminating rollers.

The ores of zinc present that metal in three states, the state of *oxide*, the state of *sulphuret*, and the state of *sulphate*.

Native oxide of zinc is called *calamine*, *lapis calaminaris*.

Its specific gravity is 3,5236.

Its colour is whitish or yellowish.

It is easy to pulverize.

The primitive form is the rectangular octahedron; but it is found in irregular plates or knobs, or in cellular, spongy, or, as it were, worm-eaten masses, of a yellow, green, red, or brown colour.

The sulphuret of zinc is known to mineralogists under the name of blend.

The colour varies considerably: it is citron, yellow, red, greenish, brown, blackish, &c. It constantly presents the appearance of a resinous body, though there is no analogy between these substances.

Blend is phosphorescent: it is sometimes sufficient to scratch it with a light body to see traces of light on the surface, in the dark.

Its texture is lamellated.

Its specific gravity is 4.1665.

When powder of blend is thrown into the sulphuric acid, an hepatic odour is disengaged.

The primitive form of blend is the rhomboidal dodecahedron.

It is also found in plates, in globules, in concentric beds, &c.

Blend is sometimes mixed with iron, gold, or silver.

Bergmann found it alloyed with cobalt, copper, and lead.

This mineral frequently accompanies the ores of lead and copper. It sometimes forms the matrix of them; and very frequently it is disposed in beds, or small veins, by the side of those of the two other metals.

The sulphate of native zinc is produced by the decomposition of the sulphuret: this is an accident, and not an ore which can be ranked with calamine or blend.

As the consumption of zinc is very limited, it has not been much worked; and almost all that is circulated in commerce comes from Rammelsberg, near Gosland, in the Lower Hartz. The process employed to obtain it from the ore is equally simple and ingenious. An inclined stone is placed in the anterior part of the furnace, in which the ore of lead, containing zinc, is fused: a great part of the zinc which is volatilized condenses upon this stone, which is carefully cooled from time to time, and flows in drops or globules into the charcoal placed at the bottom to receive it. These globules are again melted, to run the metal into a mass.

This zinc is less pure than that which is brought from India, under the name of *tutenag*.

Zinc is little used in the arts; the impossibility of malleating it, and the property it has of inflaming at a moderate heat, do not permit its uses to be very extensive.

It is employed in the composition of fireworks, in which it produces, by its deflagration, lively sparks.

Attempts have been made to substitute it for tin, in tinning copper, as it covers it better, and is harder; but as it is more difficult to apply in that manner, the preference still continues to be given to tin.

IX. *Of Bismuth.*

The characters of bismuth are the following:—

A yellowish white colour.

The specific gravity 9,0202, and 9,8227, when fused.

Fragile, reducible into grains under the hammer.

Melting in the flame of a wax candle.

Its primitive form appears to be the regular octahedron. M. Hauy obtained this figure well defined, by dividing mechanically a mass of melted bismuth.

By fusing bismuth, and running it at the moment the exterior surfaces begin to fix, we find the cavity full of crystals, which rise as it were by steps, and appear formed of an assemblage of rectangular plates, somewhat excavated like a funnel, or of wedge-formed octahedrons, and sometimes of solitary rectangular parallelopipedons.

When bismuth is dissolved in the nitric acid, it produces a considerable effervescence, accompanied by a yellowish green cloud.

It is sufficient to pour water into its solutions by the acids, to precipitate in them a white oxide, which forms the basis of the *white paint*, used as a cosmetic.

Bismuth has, like lead, the property of melting into glass by a continual oxidization; in this state it may be absorbed by the cupels; on which account it may be substituted for lead, in cupelling the precious metals gold and silver.

Bismuth is frequently found in a native state in the mines. Its most usual matrixes are quartz, jasper, and carbonate of lime. It is disseminated in these matrixes either in plates or in dendrites. It is sufficient to heat the ore to make the metal flow. The ramular bismuth of Schneeburg, which is embedded in red jasper, is capable of taking a beautiful polish, and is made into plates, which are in great request in commerce.

Bismuth is likewise found in the state of oxide: it is of a yellowish green, and easy to reduce into metal. When it is in the state of a fine and silky powder, it is called *flowers of bismuth*.

This metal is also combined with sulphur in some known ores. The mineral is then very fusible; its colour is a leaden grey, sometimes with a yellowish tinge: it may easily be cut with a knife. It divides into quadrangular prisms, which are subdivided by two very distinct sections, in the direction of one of the diagonals of their bases.

The fusibility of bismuth renders the working of it very simple and easy. It is sufficient to expose the mineral to a moderate heat to

extract from it the metal. It is merely thrown on burning coal, and it flows into a receiver, whence it is taken to give it the form of plates or ingots.

Bismuth is only used for the preparation above mentioned, called *white paint*, or to alloy with lead, to which it gives hardness.

The white paint, which is obtained by precipitating, by the aid of water, the oxide of bismuth from its solution in the nitric acid, always retains a little of the acid, which may render the use of it dangerous. This inconvenience is obviated by washing the precipitate with water slightly alkaline.

As the oxide of bismuth blackens by the action of sulphureous emanations, and even by animal transpiration alone, it has been made the basis of some pomatums which are used to give the hair a black colour.

X. *Of Cobalt.*

Cobalt is also called *cobolt*, and it is found under these two names in the different works which treat of it.

Its characters are, that it has the white colour of tin; that its specific gravity is 8,5384; that it is fragile, and easy to pulverize; very difficult to fuse; soluble in the nitric acid; and that it colours glasses blue when they are melted with it.

It appears that cobalt partakes with iron the magnetic properties. M. Tassaert purified with all possible care a large crystal of cobalt of Tunaberg, to deprive it of its iron to the last particle; and yet this metal, thus purified, acted strongly by attraction on each pole of a magnetic needle.

It seems to be difficult to make cobalt crystallize: hitherto it has only been possible to obtain some superficial striæ, which intersect each other, and form a kind of net-work. Romé de Lisle, however, assures us that he had seen groupes of small cubical crystals in the cavities of a large mass of cobalt.

Cobalt, like the other metals, is found in the mines in the state of oxide combined with sulphur, arsenic, and the arsenical acid.

Arsenic is almost inseparable from this metal, on which account it has received the name of *cobalt*, which signifies in German *an evil being*.

Arsenical cobalt has the white colour of silver when it is in crystals, and a tinge more or less reddish when in shapeless pieces. Its specific gravity is 7,7207 ; its fracture is rugged, with a fine and close grain.

The nitric acid attacks it with effervescence. Its fragments presented to the flame of a wax candle diffuse a vapour, accompanied by a very sensible odour of garlic.

The octahedron is its most usual form ; it is also found in knobbed masses.

The alloy of cobalt and arsenic is sometimes united to sulphur, which forms *grey cobalt*. The colour is a metallic white, shaded with grey. The primitive form is the cube. It dissolves in the nitric acid, diffuses an alliaceous odour with the blow-pipe, and frequently gives sparks with steel. Its specific gravity is 6,3391 —6,4509.

The grey cobalt of Tunaberg afforded M. Klaproth 44,0 of cobalt, 55,5 of arsenic, 0,5 of sulphur. M. Tassaert found in the same ore 49,00 arsenic, 36,66 cobalt, 5,66 iron, 2,18 sulphur.

Brandt found at Bastnaes, in Sweden, an ore of cobalt without alloy of arsenic. An analysis proved the existence of iron in it.

When the natural alloy of arsenic and cobalt effloresces, or is decomposed, the result is what is termed *flowers of cobalt*, in which the metal is united to the arsenical acid. The colour is the violet red of the lees of wine, approaching that of the peach-blossom when not very deep. It is sometimes found in divergent needles, parting from one common centre, and forming handsome rosettes on the surface of the matrix.

The oxidized cobalt which is found in the mines, has almost always a black, or blackish blue colour. An almost metallic lustre is given to all the surfaces which are rubbed with a hard and polished body. It is sometimes found in knobs, and very frequently in a black dust, resembling a vitreous and pulverulent scoria.

This black oxide is found mixed with silver, nickel, and frequently with earthy substances, forming masses which present variegated tinges of red, greenish, brown, &c. Native silver is very commonly seen in it, twisted in filaments; and it is this ore which is known by the name of *goose-dung coloured silver*. M. Schreiber, who analyzed a specimen of this, brought from

the mountain of Chalanches, near Allemont, in Dauphiné, obtained from 100 parts 12,75 of silver, 3,5 of iron, 43 of cobalt, 4,75 of mercury, 15,25 of water and sulphuric acid, and 20,75 of arsenic.

The treatment of the ores of arsenical cobalt, the only ones which are worked with advantage, is confined to torrefying the mineral in reverberatory furnaces, terminated by a long chimney, in which the vapours are received. These vapours, which are only the oxide of arsenic volatilized, attach to the sides, and form there a crust, which is taken off by men who have been condemned to death for crimes they have committed.

Cobalt, deprived of arsenic, and brought into the state of oxide, is known in commerce by the name of *zaffre*. It is mixed with one half or three quarters sand, and one part of good potash, to form a glass, which, when stamped, sifted, and pounded, forms the *blue of smalt*. Different degrees of fineness are given to it by shaking the pounded smalt in vessels full of water, having three apertures at different heights. The water which flows out on turning the highest cock, carries with it the finest

part, which forms, in the language of artists, the *azure of the first fire*, the second cock gives the *azure of the second fire*, and the third that of the *third fire*.

The mines of Bohemia and Saxony alone, have hitherto furnished all the cobalt, all the arsenic, and all the azure of commerce. The Count de Beust had undertaken to work a mine in the valley of Giston, in the Pyrenees, but the revolution caused the speculation to be suspended; which, however, it would be very advantageous to resume. Some traces of a mine of cobalt have been found in Dauphiné; and it were to be wished that researches of this kind might be pursued, to deliver us from the necessity of supplying ourselves from a foreign country with an object of very great utility.

This azure colours starch, and is the only principle by which enamels, porcelains, and glasses, can be coloured blue.

M. Thenard has proved that zaffre passes into blue before it is vitrified, which furnished him with the means of obtaining a colour which will mix with oil, and capable of supplying the place of ultramarine. We shall speak of it hereafter.

XI. *Of Arsenic.*

Arsenic has the following characters:—

It is of the grey colour of steel.

It diffuses a very sensible odour of garlic when it is heated and when it evaporates.

Its specific gravity is 8,308 when it is fused: that of native arsenic is only 5,7249.

It is very fragile.

Native arsenic is likewise called *testaceous arsenic.* It is found in tubercules composed of concentric beds: it is also met with in earthy and friable masses.

Arsenic is sometimes found in the state of oxide in ores; but its most natural combinations are with sulphur, or with other metals.

The sulphurets of arsenic are either yellow or red: the first is still known by the name of *rubine of arsenic*, *realgar*, or *red sulphur.* It acquires resinous electricity by rubbing. Its specific gravity is 3,3384. It yields to the pressure of the nail. It is usually translucent, sometimes transparent. Its primitive form is that of the octahedron in scalene triangles.

It is volatilized by fire, diffusing an odour of garlic and sulphur.

Bergmann, who analyzed the sulphuret of red arsenic of Pozzuoli, extracted from it 90 of oxide of arsenic and 10 of sulphur.

The Chinese employ realgar to make pagodas, cups, &c.; it is likewise used for painting.

The sulphuret of yellow arsenic, called also *orpin, orpiment, yellow arsenic,* and has a specific gravity of 3,4522. It acquires resinous electricity by rubbing. It is tender, and a little flexible. It is made use of for painting.

It was believed, for a long time, that the difference between the two sulphurets proceeded from the difference in the quantity of sulphur, which was supposed to be greater in the red than in the yellow. It appears, however, from late experiments, that the only difference consists in the proportion of oxygen, which is greater in the yellow than in the red.

Arsenic in its pure state has all the metallic characters; but it contracts some of the properties of salts when it is united to oxygen: it becomes soluble in water, and is very volatile.

This metal is little used in the arts, and it cannot compensate by any of the uses made of it, of which not one is absolute and exclusive, the great evils with which it every moment threatens the human race. It were to be wished, either that it had remained unknown, or that it were banished from commerce.

XII. *Of Manganese.*

Specific gravity 6,85.

A little malleable.

Of a metallic whiteness.

As difficult to fuse as iron.

Oxidizing easily, and passing by degrees to a black colour.

Colouring the glass of borax violet.

This metal, which is every where found in the state of oxide, has been successively taken for an ore of iron or of zinc. It is to the labours of Scheele and Bergmann that we are indebted for almost all our knowledge with respect to this substance.

Long before its true nature was ascertained, it was used in glass-houses to discolour glass,

and was known by the name of *glass maker's soap*. It was observed, that when too great a quantity of it was put into glass, the glass became of a violet colour; and that when the mixture was not well stirred and kneaded after the manganese was added, there were parts of the glass tinged of a violet colour, while other parts were more or less discoloured.

The oxide of manganese is almost constantly black. It dyes the fingers, and colours the glass of borax of a violet colour. Its hardness varies according to the nature of the bodies with which it is mixed.

It is found in thin coats, more or less soft, on the surface of hæmatite iron.

It forms dendrites on the surface of some stones: it lies in veins in granite, and forms in it small beds, in which the manganese appears to have found a retreat, which has divided it into prisms. This is observable in the granites of the Cevennes, near Saint Jean de Gardonenque.

It is sometimes *radiated*, or disposed in divergent needles round a common centre; and sometimes *interlaced*, or figured in needles, crossing each other in all directions.

Oxide of manganese is found united to iron, to barytes, to carbonate of lime, to silex, &c.

The use which has lately been made of the oxigenated muriatic acid, which is prepared by the distillation of the muriatic acid on the oxide of manganese, has given a value to this metal. Till then its utility was confined to the use made of it in the glass manufactories.

As the oxide is only used, and the metal itself is not recommended by any utility, the treating and melting of the ore has not been much practised or attended to.

XIII. *Of Antimony.*

Antimony is still known in commerce under the name of *regulus*, a generic denomination given to all metallic substances brought into the state of metal, but which is applied to this without any other designation.

The colour of antimony is the white colour of tin.

The specific gravity 6,7021.

The consistence very fragile, and the texture lamellar.

It evaporates with the blow-pipe in a white smoke, and dissolves in the nitric acid, leaving a whitish deposit.

It divides into the regular octahedron, and the rhomboidal dodecahedron.

The surface of antimony, when suffered to cool gently, is adorned with a kind of very apparent star with divergent rays. This is a feeble sketch of the work of crystallization, which may be observed in some other metals, but in a manner less distinct.

When antimony is melted into a globule on charcoal with the blow-pipe, and thrown on the ground, the globule inflames, and divides at the moment of its fall into a multitude of inflamed globules, which form so many small stars. Tin and iron produce a similar effect.

No metal has more than this exercised the patience of alchemists, who, in pursuing a chimerical object, have formed compositions of antimony equally numerous and varied, of which medicine has availed itself with much success. This metal furnishes the most active medicines, and such as at the present time are most employed. The use of them no doubt requires a very cautious hand, on which ac-

count they were prohibited by the Parliament of Paris. But to have enforced the prohibition would have been to deprive medicine of one of its greatest resources.

Antimony has been discovered native at Salberg in Sweden, and near Allemont in Dauphiné, where it is also found alloyed with arsenic.

The most common mineraliser of antimony is sulphur. In this state it is called *ore of grey* or *sulphureous antimony*. The characters of this sulphuret are the following:

Specific gravity 4,1327 to 4,7165.

Colour approaching the grey colour of steel.

Sulphureous odour when rubbed.

Fragile by the mere pressure of the nail.

Fusible in the flame of a wax candle.

Divisible by pretty smart blows in one single direction.

Parallel to the axis of the crystals.

The sulphuret of antimony, such as that of Auvergne, furnishes superb groups of crystals, in which we see pyramids with three or four sides, placed against other pyramids, which meet in one common centre. Those of Hungary, Siberia, and other ores, sometimes pre-

sent parcels or assemblages of divergent or fasciculous fibres, tinged with the richest colours, and displaying the polish of steel. These ores usually contain silver, and are denominated ores of *plumose*, or *feathery silver*.

It is also found in large specular plates, which reflect like mirrors, and which originate in the fragments of prisms.

Antimony likewise presents itself to mineralogists in the state of oxide. It is of a mother-of-pearl white colour, fusible in the flame of a wax candle, and very easy to cut with a knife. It decrepitates on burning charcoal, and is evaporable into smoke with the blow pipe. M. Vauquelin obtained from it 86 oxide of antimony, 8 silex, 3 oxide of antimony mixed with oxide of iron. This oxide is found likewise in rectangular plates, and in divergent needles.

Naturalists likewise describe a natural combination of oxide of antimony, the acid of arsenic, and sulphur, which has been taken for the native kermes, in which M. Berthollet has demonstrated the existence of oxide of antimony, sulphur, and hydrogen. This ore is evidently a decomposition of a sulphuret of antimony and arsenic, which forms the kermes

by the presence of the latter metal, and approaches it in colour, and other principles.

Antimony is found in commerce in two states, *crude antimony* and *regulus* or metal.

Crude antimony is only sulphureous antimony disengaged from its matrix; it is a sulphuret of antimony. The process used to bring it into this state is very simple. The mineral is put into pots having a hole in the bottom, which are placed on other pots bedded in the earth. The upper pots which are filled with the mineral, are heated. The antimony becomes fused, and flows into the lower pots, while the small quantity of the matrix which adhered to the sulphuret, remains in the upper pot. The mass of the sulphuret fixes, and forms cakes of the shape of the pot which receives them. It presents, in its fracture, a surface thick set with needles, which, standing by the side of each other, compose, as it were, the whole of the mass.

Some ores of antimony do not contain a sufficient quantity of sulphur, and in that case it is added, to give to the product a constant quality and colour.

In order to extract the metal from the ores

of antimony, they are first torrefied ; afterwards one part of desiccated wine-lees, or tartar, is mixed with two parts of oxide of antimony, and this mixture is fused in crucibles.

Antimony may likewise be disengaged from its sulphur by melting it with copper, silver, or iron.

Antimony is used in the composition of printing types, in which it is mixed with lead in the proportion of about one fifth.

It gives hardness to tin, and enters into the composition of metallic mirrors.

What has been known under the name of *prince's metal*, was an alloy of 18 parts of tin to 100 of antimony : various kinds of utensils are made with this alloy, which unites a fine polish and the brilliancy of silver to great hardness.

XIV. *Of Nickel.*

Mineralogists, after having successively treated nickel as a modification of iron or copper, have now agreed to consider it as a particular metal, which has the following properties :

Specific gravity, 9.

Of a greyish white.

Acting by attraction on the magnetic needle, and capable of acquiring poles.

Reducible into a green oxide by heat.

Sensibly ductile when it is divested of all foreign matter, and capable of being laminated.

The substance which usually furnishes nickel, is that which is called *kupfer-nickel.* It contains, besides nickel, arsenic and iron, from which it is difficult to disengage it.

M. Klaproth has discovered that the colouring principle of the chrysoprase is nickel. The metal which he obtained from it by analysis, acted upon the magnetic bar like that extracted from the ore; whence he was inclined to believe, that nickel partakes with iron in the magnetic properties.

M. Hauy having operated on nickel purified with the greatest care by M. Vauquelin, is of opinion, that nickel possesses in itself magnetic properties.

Arsenic accompanies nickel in some of its ores; copper is found almost constantly in this alloy, the colour of which is a reddish yellow, and the specific gravity from 6,6086 to 6,6481.

Nickel also exists in some ores in the state of oxide: it frequently covers the ores of arsenical cobalt, in the form of a kind of green crust.

No use has yet been made of this metal.

XV. *Of Platina.*

If platina be considered only with respect to its specific gravity, its unalterability by the air and by fire, and its insolubility by the simple acids, this metal ought to be placed first among the known metals; but when we observe that analysis discovers every day new metals which are naturally mixed with it, and that, by consequence, what we call *platina* is a natural alloy, in which indeed the metal platina predominates so far as to form almost the whole of its weight, but of which, nevertheless, the individual properties are not ascertained, abstracted from all alloy; we find ourselves forced to place it here, till analysis shall have assigned it its natural rank.

The characters of platina are the following:

Colour, a silvery white, between that of steel and that of silver.

Specific gravity 20,980, according to Borda, when it is hammered and purified. That of gold is only 19.

The least fusible of the metals.

The hardest, next to iron

The most ductile, next to gold.

The most tenacious, next to gold, iron, and copper

Borda has ascertained that its relation of dilatability for each degree of the centigrade thermometer, is $\frac{1}{11\,5000}$.

Platina is soluble only in the nitro-muriatic acid.

Before the discovery of M. Vauquelin, who found a tenth part of platina in the silver ores of Guadalcanal in Spain, this metal had only been found in the gold ores of South America. When these ores are divested of their matrix, and the gold is separated from them by the means of mercury, the platina remains alone, in the form of small grains or spangles. It always retains a small quantity of mercury, which is disengaged from it by heat. There have been found grains of platina, though indeed they are rare, of some lines in length. M. Humboldt brought one home when he returned

from his travels, which is at least of the size of an almond; and M. Gillet-Laumont possesses one which is about five lines in length and three in breadth, and weighs 40 grains. Platina suffers no alteration from the air.

Macquer and Beaumé have kept platina in the fire of a glass furnace during several hours, but its grains underwent no alteration, they were only a little softened, and contracted a feeble adherence to each other.

Platina becomes fused in the focus of a burning mirror, and by the heat of flame excited by vital air.

But all these means only ascertain the fusibility of platina, without enabling us to fuse it in a quantity sufficiently large to employ it in the arts. This has induced chemists to give their attention to this metal, that they might at length be able to work it. Of all the processes which have best succeeded, those in which arsenic or phosphorus are employed, appear to have obtained the preference. M. Achard has proposed to take equal parts of platina, white oxide of arsenic, and acidulated tartrite of potash: this mixture is put into a crucible, and exposed, during an hour, to a

violent heat. The platina fuses, but it is brittle, fragile, and whiter than common platina: this alteration proceeds from the arsenic which remains alloyed with it, and which must be disengaged from it by heat. So that to work platina, advantage is taken of its state of alloy with arsenic, which renders it more fusible; and it is run in moulds, and again exposed to a heat sufficient to disengage all the arsenic. As the arsenic evaporates, the platina is hammered, to prevent the porosity which would result from the departure of the arsenic.

M. Guyton Morveau has substituted with advantage, the arseniate of potash for the oxide of arsenic: I have myself employed it with success.

Pelletier has fused platina by mixing with it phosphoric glass and charcoal: in this case, the phosphorus unites with the platina, and is afterwards separated from it by heat.

Platina is susceptible of being alloyed with bismuth, antimony, zinc, tin, lead, copper, iron, silver, and gold.

When platina is alloyed with a metal soluble in the acids, it may be separated from it by dissolving the metal: the platina is then more

fusible. It is the same with platina precipitated from its solution in the nitro-muriatic acid. Gold cannot be alloyed with platina, but by an extremely violent heat: the colour of the gold is much altered by it, and the alloy is tolerably ductile.

This metal is already of very valuable use in the arts. It receives a perfect polish which does not change: it is almost infusible; it is only attacked by the nitro-muriatic acid: these are the properties which render it extremely useful in many delicate operations in our laboratories. Of it are made crucibles, retorts, ladles, vessels for evaporation, the place of which cannot be supplied by any other metal.

The density and inalterability of platina render it likewise valuable for making mirrors for reflecting telescopes. It is preferable to steel, from its being unchangeable by the air, and more compact; and to glass, because it presents only a simple image. To work it with more facility, M. Rochon alloyed it with copper and tin.

The experiments of MM. Fourcroy and Vauquelin, induce us to hope that the working of platina will be rendered much more easy,

and the metal more brilliant, when the operations shall be performed on a platina purified from all alloy. I have myself seen a large capsule made of pure platina, and it was easy to perceive, at the first glance of the eye, the superiority of the colour; the maker, at the same time, vouched for the facility he found in working it.

Every thing inclines us to believe, that by purifying platina from the metals which are alloyed with it, it may be worked with sufficient ease and cheapness to be applied to many new uses.

The platina of commerce, that which has hitherto been worked, and from which have been ascertained all the properties that are attributed to this metal, is nevertheless mixed with many other metallic substances. Iron is almost inseparable from it, and to such a degree, that Buffon considered it as a natural alloy of gold and iron; but, in our time, several metals have been discovered, that have not hitherto been found except in this alloy. It has long been known, that from the solution of platina by the nitro-muriatic acid, a black powder is precipitated, on which M. Fourcroy, Vauquelin,

and Descotils, have made, at the same time, different experiments, which led them to believe that this oxide, which has a pungent odour and a particular savour, which is sufficiently volatile to pass in distillation with water, which easily yields its oxygen, and is reduced into a very fixed metal, appertained to a new metal

Mr. Tennant, informed of the discoveries of the French chemists, subjected the black powder to a new examination, treating it successively with potash and the muriatic acid, according to the method of MM. Fourcroy and Vauquelin; and he discovered that the properties which had been confounded, appertained to two very distinct metals, of which the one, in a state of oxidation, was more easily dissolved in alkali, and the other in the muriatic acid. He distinguished the properties of each of these metals, and he called the former *osmium*, on account of the odorous quality of its oxide, and the other *iridium*, from the various colours its solution by the muriatic acid exhibits.

The subject, however, was not exhausted, and Mr. Wollaston found in the solution of

platina, besides the copper, iron, and lead contained in it, two new metals, one of which he called by the name of *palladium*, and the other by that of *rhodium*, in reference to the rose-colour which it gives to the nitro-muriatic solution.

The results stated by M. Wollaston, have been confirmed by M. Descotils.

Platina, purified by mechanical means, was exposed to a strong heat, to drive out the mercury: it was then digested in a small quantity of nitro-muriatic acid, and diluted with water, to separate from it the gold.

Afterwards the platina was dissolved in the nitro-muriatic acid, the action of which was moderated to obtain as much as possible of the black powder which contains the *iridium* and the *osmium*. The solution was precipitated by the muriate of ammoniac, which carried off the greater part of the platina, forming a yellow combination. A plate of zinc was put into the clear solution, which precipitated all the metallic substances except the iron. This precipitate, which is of a black colour, contains platina, rhodium, copper, and lead: the copper and lead are dissolved by the nitric acid

diluted; the remainder is digested in the nitro-muriatic acid weakened, which dissolves the whole, except a small portion which remains insoluble, and which is *iridium:* muriate of soda is added to this last solution, and it is evaporated to dryness: a salt is obtained, composed of muriate of soda and platina, palladium and rhodium; but the muriate of soda and platina are dissolved in alcohol, as also that of the palladium; while that of the rhodium is insoluble in it, and is therefore separated by this means.

The platina is precipitated by the muriate of ammoniac, and after having diluted the liquor, the palladium it precipitated by the prussiate of potash.

Thus we find there are eight metals mixed together to form platina. Though seven of them exist in it but in very small quantity, this alloy is one of the most extraordinary things with which we are acquainted; and the analysis of platina, one of the surprising proofs of the superiority and perfection of the present means of chemistry.

XVI. *Of Tellurium.*

Tellurium is characterised by the following properties:

A specific gravity of 6,115.

Extremely fragile.

The white colour of tin, approaching a little to the grey of lead.

A lamellar structure.

Burning with the blow-pipe, with a rather lively flame of a blue colour, a little green towards the edges: it afterwards volatilizes in a white cloud, diffusing an odour resembling that of the radish.

Though tellurium exists in the bowels of the earth in a native state, it has hitherto been found alloyed with gold or iron, silver or lead. Its alloy with gold and iron is known by the name of *white gold*. At Naygag in Transylvania, it is united with six metals, which are antimony, arsenic, lead, iron, silver, and gold, and it is called *ore of gold of Naygag*.

Native tellurium containing iron and gold, has a specific gravity of 5,723; a colour approaching the whiteness of tin, but darker;

and a tender and fragile consistence. Treated with the blow-pipe, it at first decrepitates, then melts like lead, and burns with a lively and brownish flame, diffusing an acrid odour, and leaving a residue resembling silex. M. Klaproth obtained from 25,5 of tellurium, 72,0 of iron, 2,5 of gold.

Native tellurium containing gold and silver, has the same characters as the preceding, and afforded M. Klaproth the following results: 60 of tellurium, 30 of gold, 10 of silver.

Native tellurium, containing lead, gold, and silver, has a specific gravity of 8,919; its colour a dark metallic grey, and a tender consistency. It afforded M. Klaproth, lead 50, tellurium 33, gold 8,5, silver and copper 1, sulphur 7,5. A yellowish variety of the same species gave him 45 tellurium, 27 gold, 19,5 lead, 8,5 silver, and an atom of sulphur.

Native tellurium crystallizes in very short, regular, hexahedral prisms: it is also found in plates, which are easily separated in the direction of their large faces, which are brilliant and somewhat rough.

We are acquainted with this new metal only from the analysis given of it by M. Klaproth,

in 1798. Muller, however, having analyzed the white gold, speaks of a residue which forms the greater part of it, and which has all the characters of a new metal. Mr. Kirwan introduced it a short time afterwards into his *Elements of Mineralogy*, under the name of *Sylvanite;* but M. Klaproth has not only proved the existence of this metal in the ores of Fatzbay and Offenbany, but he first shewed that it was to be found in the gold of Naygag.

To obtain this metal, the ore is gently heated with six parts of the muriatic acid; then adding three parts of nitric acid, the mixture is made to boil: a very considerable effervescence is produced, and a complete solution obtained, which is diluted with a little water. To the liquor is then added a solution of caustic potash, till the white precipitate, which is at first formed, disappears, and there remains only a brown and flaky deposit. This latter precipitate is oxide of gold and iron.

To the alkaline solution is added muriatic acid to saturation, which produces a white precipitate. This precipitate is washed, dried, and formed into a paste with a fat oil, which is heated to a red heat in a retort. Metallic

drops or particles arise and fix on the sides of the retort; and after cooling, besides the metal sublimed in drops, and attached to the sides of the retort, some is found at the bottom of the vessel.

XVII. *Of Chrome.*

In 1789, MM. Macquart and Vauquelin gave an analysis of the red lead of Siberia, and announced that this mineral was an intimate combination of hyperoxygenated oxide of lead with iron and alumine.

Since that time M Biodheim has said, that he has found it copper, cobalt, nickel, iron, and the molybdic acid.

In the beginning of 1798, M. Vauquelin resumed his experiments on this substance, and discovered a new metallic acid, which he called the *chromic acid*, and the metal *chrome*, because it colours the combinations into which it enters.

A hundred parts of pulverized red lead, mixed with 300 parts of saturated carbonate of potash, and about 4,000 parts of water, were

subjected to ebullition during an hour : at first a lively effervescence is produced, which continues a long time ; the orange-tinged colour of the lead becomes of a brick-like red ; the liquor assumes a beautiful golden yellow colour, and there remains an insoluble metallic powder, weighing 0,78 ; there are therefore 22 parts dissolved in the potash. Nitric acid, diluted with 12 parts of water, is then poured on the metallic powder : a strong effervescence is produced, the greater part of the matter is dissolved, the liquor takes no colour, and there remains only a small quantity of a citron yellow colour. This residue, dried and washed, does not weigh more than 16 parts : 42 parts of carbonate of potash, boiled with a sufficient quantity of water on the 16 parts of the residue, left only two parts of true red lead, which were neglected. The nitric solutions contain the lead.

The alkaline liquors mixed and evaporated to a pellicle, produced, on cooling, yellow crystals, among which there was undecomposed carbonate of potash.

These crystals were dissolved in water, and the solution mingled with the mother-water, was mixed with nitric acid weakened to satu-

ration with carbonate of potash. Evaporation produced red ruby crystals, intermingled with crystals of nitrate of potash. This solution, mixed with the solution of nitrate of lead, regenerates the red-lead.

The mineralizing acid of red-lead forms 36,00 parts of the whole.

The chromic acid gives with potash a salt of an orange colour.

It precipitates the mercury from the nitrate of a deep cinnabar colour. It forms in the solution of nitrate of silver, a precipitate of the most beautiful carmine red, which becomes purple in the light.

It forms a chesnut-red precipitate with nitrate of copper.

The chromic acid fused with borax, communicates to it a deep green colour.

Paper which has imbibed the chromic acid, assumes a greenish colour in the light.

The concentrated muriatic acid distilled on the chromic acid, passes into the state of oxygenated muriatic acid, and the liquor takes a beautiful green colour: the mixture of these two acids dissolves gold.

The sulphuric acid causes this acid to assume

a blueish colour, when it is digested upon it with heat.

The sulphureous acid passes into the state of the sulphuric acid.

Seventy-two parts of chromic acid, put into a charcoal crucible, placed in another of earth filled with charcoal-dust, were reduced by a fire of half an hour in a forging furnace, to a metallic mass of a greyish-white colour, formed of interlaced needles, and weighing 24 parts.

Properties of Chrome.

Chrome is white, of a greyish-white colour, very fragile, infusible, and fixes and crystallizes in needles.

Exposed to the heat of the blow-pipe, it becomes covered with a lilac crust, which turns green when it has cooled.

Treated with the blow-pipe with borax, it does not oxidize, but a part, after being oxidized, dissolves in the salt, and communicates to it a very beautiful green colour.

The acids have but a very feeble action on it. The nitric acid is the only one which causes it

to undergo any remarkable change: it is converted into an orange-yellow powder, by distilling five or six times successively, twenty parts of this acid upon one of the metal. This powder is acid, dissolves in water, combines with alkalies, from which it disengages the carbonic acid, and precipitates metallic solutions with the same phenomena as the chromic acid.

The analysis of the spinell ruby also afforded chrome to M. Vauquelin.

M. Klaproth found in it—

Alumine	76
Silex	15
Magnesia	8
Oxide of iron	1.5

M. Vauquelin took 400 parts of spinell ruby pulverised and heated it during an hour in a silver crucible, with 1600 of caustic potash: the mixture did not fuse.

He diluted this matter in distilled water, which almost entirely dissolved it, there only remained 12 parts He poured weakened muriatic acid on the solution, with which the undissolved matter remained mixed.

The first portions of the acid brought the

liquor into a white mass, like a thin paste, which was again dissolved, for the most part, by fresh quantities of acid.

He gently heated and filtered the solution: there remained on the paper 12 parts of a rose-coloured powder, which was still the matter of the ruby unaltered. It was taken away, that it might not act on the decomposed part.

The muriatic solution upon it having been evaporated to dryness by a mild heat, he poured on the saline remainder a great quantity of distilled water: almost all of it was dissolved; nothing remained but 20 parts of a grey powder, which, fused with borax, communicated to it a light green colour.

He treated this 20 parts with nitric acid a little concentrated: the liquor assumed a green colour, and the insoluble residue became white: this residue, washed and dried, formed 12 parts: it was pure silex taken from the mortar.

The muriatic dissolution, as well as the dissolution by potash, and that by the nitric acid, afforded, by their decomposition, alumine, magnesia, and chrome, in the following proportions—

Alumine	86,00	
Magnesia	8,50	99,75.
Chromic acid . . .	5,25	

M. Vauquelin likewise extracted 3,50 of oxide of chrome from the emerald of Peru.

XVIII. *Of Titanium.*

This new metal, called *titanium*, *titane*, or *titanite*, was found by M. Klaproth in the red schorl of Hungary.

After that time M. Klaproth shewed, that a fossil of the bishopric of Passau in Germany, contained one third of oxide of titanium, united to lime and silex.

And MM. Vauquelin and Hecht having analyzed the red schorl which MM. Miché and Cordier had found in the canton of Yrieix, in the department of Upper Vienne, recognized in it the same principles which the chemist of Berlin had shewn to exist in that of Hungary.

These two chemists in like manner demonstrated the existence of oxide of titanium, united with iron and manganese, in a fossil

of Bavaria which had been taken for an ore of tin.

The red schorl of Hungary is found at Boinik, in a rock of quartz intermixed with beds of micaceous schistus: its colour is a clear brownish red.

The specimens which M. Klaproth possesses, present the form of a rectangular parallelopipedon strongly striated, or furrowed lengthwise; the broadest are of about half an inch; commonly they are thinner, and frequently they are found in the form of needles. The surface of the crystals is striated, and very brilliant; the fracture crosswise is leafy: they are easily broken, but it is difficult to pound them. The specific gravity is 3,180.

Two hundred parts of this pulverized fossil, mixed with 1,000 parts of carbonate of potash, were heated to a red heat in a porcelain crucible. The mixture easily entered into fusion. When poured on a plate, it fixed in a solid mass, of a whitish grey colour, with needles on the surface, and the fracture of which was fibrous. It was pounded, and put into boiling water. It soon deposited a white powder, which, dried, formed 328 parts of the whole.

The liquor, which had been passed through the filter, saturated and precipitated by the muriatic acid, gave a deposit of 8 parts of a mucilaginous earth, containing half silex and half alumine.

The white earth insoluble in water is the oxide of titanite mixed with a little silex.

A hundred parts of the red schorl of France were fused in a crucible, with 600 parts of carbonate of potash. This melted mass, put into boiling water, deposited a white powder with a slight tinge of rose colour, which washed and dried weighed 157 parts. The alkaline liquor, decanted and analyzed with care, contained a small quantity of silex and alumine: it held in solution caustic potash. It is therefore proved that the white powder takes carbonic acid from the potash, which renders it effervescent.

Before the existence of a metal in the red schorl was suspected, it was used in the manufacture at Sevres to colour porcelain brown. With this substance was coloured, among other productions of art, the beautiful vase known by the name of the *cordelier*, now exhibited in the gallery of St. Cloud.

By the same process, the existence of oxide of titanium, in the different substances in which it is met with, has been sufficiently proved.

The fossile of the bishopric of Passau, in which M Klaproth found 0,33 of oxide of titanium, has the form of a rhomboidal tetrahedral prism, from one quarter of a line to three lines in length. These crystals are of a dark brown, approaching to green or grey. The surface is smooth and shining. The fracture breadthwise is rather dull; in the direction of the length it is of a middling brilliancy. The smallest crystals are transparent, the largest only so at their edges, and sometimes they are even opake. These crystals are fragile and difficult to pulverize They are usually found scattered in a rock, of a coarse grain, of which the greater part is composed of felt spar, which is white, greyish, or approaching to yellow; and which likewise contains horn blend, quartz, mica, and steatite. The specific gravity of these crystals is 3,510.

The fossil of Bavaria, on which MM. Vauquelin and Hecht operated, is found at Bodenmais, in Lower Bavaria. It is in little rolled

crystals: its colour is black; its specific gravity is 37,00; while that of the French titanite is 42,00, and the colour of the latter a brownish red.

The white matter which is extracted from these different fossils by the carbonate of potash, has the following characters.

1. Treated alone in a crucible, it loses 0,25 of its weight, and takes a yellow colour, which disappears when it has cooled. It then will not dissolve in the acids, nor does it effervesce with them.

2. Ignited alone on charcoal with the blow-pipe, it takes a citron yellow colour, which it loses on cooling.

3. Ignited with the blow-pipe on charcoal, with phosphate of soda and ammoniac, this substance flows easily, and forms a globule homogeneous in all its parts, and of a violet colour in its fragments.

4. Treated in the same manner with borax, it forms a transparent globule of a topaz yellow.

5. With the carbonate of soda it at first appears to fuse; but the matter afterwards extends upon the spoon, on which it forms an pake crust.

6. This white matter is carbonate of titanium.

This carbonate of titanite dissolves with effervescence in the sulphuric acid.

The nitric and muriatic acids attack it with violence; but heat precipitates all the oxide of this solution, because in this case the proportions of the oxygen in the oxide change, which then renders it insoluble. The nitrous solution heated, gives nitrous gas, and precipitates the oxide, while the muriatic solution gives oxigenated muriatic acid. In the former case there is, therefore, a decomposition of the acid on the oxide; in the latter, there is a decomposition of the oxide on the acid. Thus, for the solution to be made in the nitric acid, it is necessary that it should be much less oxidized than when it is intended to effect the solution by the muriatic acid.

The oxigenated muriatic acid dissolves a little of the carbonate of titanium.

The acetic acid takes up also a small quantity.

The acid solutions of the oxide of titanium are precipitated.

1. By the carbonate of potash, in a white and flocculent matter.

2. By ammoniac in the same manner.

3. The infusion of gall nuts forms a reddish brown precipitate. This precipitate, washed and dried, resembles kermes mineral.

4. The arsenic and phosphoric acids occasion a white precipitate.

5. The tartareous and oxalic acids form a white deposit, which in a moment is re-dissolved

6 Tin precipitated by the solution of muriate of titanium has a pale rose colour, which soon assumes the beautiful colour of the ruby.

7. Zinc changes the colour of the same solution into violet, which by degrees passes into indigo blue; heat discolours it: it precipitates a white powder, which, re-dissolved in the same acid, resumes the same properties.

8 The sulphuret of ammoniac, combined with a similar solution, gives birth to the colour of a dirty green, and forms a precipitate of a blueish green. When sulphuret of ammoniac is poured upon the white earth, it in an instant assumes a greenish blue colour.

9. The prussiate of potash, mixed with the acid solutions of titanium, produces in them a green precipitate, which does not become blue

in the air, like that of iron. This prussiate of titanium, in the liquors in which it has been formed, is decomposed by the alkalies, passing through different shades of colours, which succeed each other in the following order—light, purple, blue, white.

Seventy parts of carbonate of titanium were mixed with fish oil. This mixture, placed in a Hessian crucible filled with fine charcoal dust, and subjected for an hour and a half to the action of a violent fire, afforded a blackish blistered substance, some of the points of which had a metallic reddish colour.

Fifty parts of carbonate of titanium, mixed with 300 parts of a flux, (composed of one part muriate of ammoniac, 1 of pounded glass, 1 of tartar, 2 of black flax, $\frac{1}{2}$ of calcined borax, $\frac{1}{2}$ of charcoal dust,) were heated during three quarters of an hour. There was found at the bottom of the crucible a black and spongy substance, and a red pellicle sublimed to the cover of the crucible; which proves that titanite is volatile, like many other metallic substances.

Titanium is very nearly insoluble in the nitric and nitro-muriatic acids, which change the surface and cover it with a white pellicle.

The sulphuric acid, boiled upon titanium, is decomposed; the metal changes into a white powder, one part of which remains in solution in the acid. There is also a production of sulphureous acid. The sulphate of titanium has the same properties as that obtained by the solution of the oxide in the same acid.

The red schorl is therefore an oxide of titanium, mixed with a little silex and alumine.

Titanium must be classed among the fragile and oxidizable metals.

XIX. *Of Uranium:*

It is to M. Klaproth that we are likewise indebted for the discovery of this new metal.

Nature has hitherto presented it in three states: 1. The state of sulphuret; 2. The state of carbonate; 3. The state of oxide.

The sulphuret of uranium is of a deep black; its fracture is brilliant; in it is sometimes perceived plates. It was taken for a sulphuret of zinc, which was denominated *pechblende,* or pitch-blend, from its resemblance to that substance.

M. Klaproth has carried its specific gravity to 7,5 ; while M. Guyton only found it 6,3785 ; and M Hauy, who weighed another specimen, estimated it at 6,5304. The specific gravity of blend, according to Brisson, is only 4,1665, which may enable us to distinguish blend from sulphuret of uranium.

The oxide of uranium is found on the surface of the sulphuret, where it forms a yellow powder. There are also brown or blackish masses, in which the oxide of uranium is mixed with the oxide of iron. In this state it is called *uranochre*. From a piece which weighed in air $332\frac{1}{2}$ grains, M. Hauy ascertained its specific gravity to be 3,2438.

Uranium has likewise been found mixed with copper, and mineralized by the carbonic acid. This is what has been successively called *green mica*, *corneous copper*, *ponderous spar*, *chalcolithe*. It forms small square plates, with double chamfered edges. Dolomieu found very small crystals, forming complete octahedrons.

The sulphuret of uranium calcined in a retort, loses part of its weight, and gives out sulphureous acid, and a sublimate of sulphur. If

the calcination is performed in a roasting capsule, in the open air, the sulphuret at first loses weight, but regains it if the calcination be continued to a red heat.

The sulphuric acid attacks the sulphuret but feebly; but the nitric acid decomposes it completely, and separates from it the sulphur, and a ferruginous siliceous earth, which remains insoluble. The muriatic acid decomposes it imperfectly; the nitro-muriatic corrodes it, and leaves for residue the sulphur and the martial siliceous matrix.

The carbonate of potash forms in the solutions of nitrate or muriate, a precipitate of a whitish yellow. No greater a quantity of alkali than is necessary to saturate the acid must be employed, to prevent the carbonic acid, in excess, from re-dissolving a part of the precipitate. This solution gives a new precipitate of a citron yellow colour, if nitric acid be added to it.

The acids dissolve the precipitates with facility.

These precipitates treated by M. Klaproth with all the known fluxes, gave only black vitreous scoriæ, without any vestige of regulus.

This yellow oxide, mixed with linseed-oil which had been burned in a roasting capsule, was put into a Hessian crucible with charcoal dust, and exposed to a very violent fire. The result was only a heavy mass, slightly coherent, which broke between the fingers into a black powder, somewhat brilliant. This metallic residue decomposes the nitric acid with heat.

This substance had been treated at the same time, and in the same manner, with oxide of manganese, in separate crucibles: the latter was completely reduced, which proves that uranium is more difficult to fuse.

M. Klaproth exposed the imperfect product of this first reduction in a Hessian assay capsule. He covered it with calcined borax, and filled the remaining space with charcoal dust. He luted the cover, and applied a very violent heat. The regulus presented a coherent mass, consisting of very small agglutinated metallic globes, the colour of which was a deep grey: on cutting it, it appeared of a pale brown. It might be filed and scraped with a knife.

This metal undergoes no change with the blow-pipe: mixed with microcosmic salt, there

is produced on the melted globule a dull pellicle of a silver white. This globule had a grass green tinge.

M. Klaproth has determined the comparative weight of this new metal to be 6,440.

The same chemist has made the following experiments, to ascertain the colour which the yellow oxide will give to glass.

	drams.	grs.	
Prepared silex	2		Transparent glass of a clear brown.
Salt of tartar	1		
Yellow oxide	0	10	
Prepared silex	2		Opake glass of a blackish grey.
Soda	1		
Yellow oxide	0	10	
Silex	2		Glass resembling the smoaked topaz.
Calcined borax	2		
Yellow oxide	0	10	
Silex	2		Opake glass, of a clear apple green, like the chrysoprase.
Vitreous phosphoric acid	2		
Yellow oxide	0	20	
Vitrified phosphoric acid	2		Glass clear, like the emerald.
Yellow oxide	0	10	

The yellow oxide, brought to a feeble red heat, mixed with the necessary flux, gives to porcelain a deep orange colour.

XX. *Of Molybdena.*

Molybdena was long confounded with plumbago; but Scheele discovered that molybdena was a compound of sulphur and a concrete acid, which he called the molybdic acid. He did not succeed in his attempts to reduce this acid into a metal; but Hielm, the pupil of Bergmann, was more fortunate.

Molybdena is of a metallic grey colour.

It is very refractory; its grains only agglutinate a little in a violent heat.

Warmth, the air, and the nitric acid, convert it into a white oxide.

The sulphuret of molybdena is what chemists have hitherto called *molybdena.* It is of the grey colour of lead. Its specific gravity is 4,7385. It is composed of flexible plates, separable, and very unctuous to the touch. It marks paper of a metallic grey colour. By the action of the blow-pipe, it evaporates in a white smoke, exhaling a sulphureous odour.

The sulphuret of molybdena usually affects the form of very short prisms, similar to an hexagonal plate.

Saxony, Bohemia, and Sweden, furnish sulphuret of molybdena; but this substance is not a stranger to France. M. Lelievre found it in the shafts of the mine called *grande montagne du chateau Lambert*, near the Tillot.

XXI. *Of Tungstein.*

What mineralogists, until the year 1781, knew by the name of *wolfram*, and *ore of white tin*, is composed of a particular acid, united to iron and manganese in the former, and to lime in the latter. It is to the celebrated Scheele that we are indebted for this important discovery.

A short time afterwards Bergmann conjectured that this acid was a metallic acid; and after him, the brothers Delhuyar extracted from it the metal.

This metal has a specific gravity of 17,6, according to the brothers Delhuyar; but this result appears to be equivocal, for MM. Vauquelin and Hecht could only obtain this metal in a spongy mass, with small metallic grains, of a greyish white colour, and very hard and

very fragile, scattered through it: it was impossible for them to weigh it specifically. M. Guyton obtained a total of the weight of 9 drams 11 grains, from which he concluded that the specific gravity was 8,3406. It is insoluble in the sulphuric, muriatic, nitric, and nitro-muriatic acids: the two latter convert it into an oxide.

Its oxide is yellowish and acid: it is called the *tungstic* acid.

Wolfram contains this oxide alloyed with the oxide of iron, and that of manganese with a little silex. Its colour is a brownish black. Its specific gravity is 7,3333. Its primitive form is the rectangular parallelopiped. It is sometimes found in plates so closely joined that their assemblage presents the appearance of a striated texture.

The mountain of Puy-les-Mines, in the department of Upper Vienne, contains a vein of wolfram.

The *ore of white tin* contains this oxide united to lime. Its specific gravity is 6,0665. Its colour is a dirty white. Its primitive form is the cube.

Besides the new metals of which we have

spoken, there are others, the nature and characters of which have been ascertained by chemists. *Columbium*, discovered by Mr. Hatchett in 1802, and *Tantalite*, discovered by M. Eckeberg in 1801, are of this class. But we are in possession of so few facts relative to these metals, their existence appears to be so limited among the numerous mineralogical varieties of the globe, that we do not think it requisite to appropriate to them a separate article.

It results, however, from all that we have said, that, in the present state of our knowledge, we reckon twenty-seven metals, including the four new ones which are alloyed with platina.

CHAPTER III.

Of some Substances eminently combustible.

WE shall divide this title into two sections. In the first we shall treat of some simple combustible substances, as sulphur, phosphorus, and charcoal; in the second we shall treat of other substances eminently combustible, but which are compound, such as oils, bitumens, resins, &c.

SECTION I.

Of simple combustible Substances.

Though the metallic substances appertain essentially to this class, as well as hydrogen, we have thought it proper to place them elsewhere, under titles suitable to them, on account of their principal characters, or some one of their more eminent properties. We shall

confine ourselves to comprehend under this section, sulphur, phosphorus, and carbon.

I. *Of Sulphur.*

Sulphur claims to be one of the first in this class. It has a specific gravity of 2,0332 when it is native, and of 1,9907 when fused; a double refraction in a high degree, and sensible even through two parallel surfaces, and the property of crackling in the hand when it is pressed.

It burns with a blue flame, and an odour which is suffocating without being fetid. The flame lengthens and becomes white at the *apex*, when the combustion is rapid.

Its primitive form is the octahedron in scalene triangles.

If we read what the chemists who preceded Stahl have written on sulphur, we shall only be able to form a vague idea of it: they consider it as the sole principle of inflammability and colouration; and they class it among the three elements of bodies, *salt*, *sulphur*, and *mercury*.

Stahl assigned a determinate value to the term sulphur; but he fell into other errors, of the more importance, as they constituted the doctrine of the chemists during nearly a century. That able chemist thought he had proved the existence, in sulphur, of two principles, phlogiston and the sulphuric acid; and it was not till the revival of chemistry, and the discovery of the true means of analysis, that sulphur was restored to the class of simple bodies. This progress would appear to be retrograde, if we did not know that to rectify our ideas is to advance in science.

We find sulphur, in a greater or less quantity, in almost all the productions of the globe. The analysis of eggs, blood, and hair, afford it. M. Deyeux obtained it from the roots of patience and cochlearia *.

Sulphur is the most common mineralizer of metallic substances. It abounds in pyrites and

* All the species of the genus *rumex*, confounded under the name of *patiences*, do not afford it. It is not obtained from those which are natives of hot climates; while the *rumex patientia* of Linnæus, which grows in the North, or on the mountains in the South, contains it.

pit coal. The decomposition of these latter substances, which very often takes place in the bowels of the earth, occasions the volatilization of a great quantity of sulphur.

It appears, from all the observations with which we are acquainted, that sulphur only exists in substances of a secondary formation; those which constitute the basis of our globe, as the primitive rocks, do not contain it; and though we are not authorized, in the present state of our knowledge, to consider sulphur as a compound body, the fact which we have just stated, and the following observations, that this mineral substance is produced every day, and that it is to be presumed that a long time will not elapse before we shall be able to discover its principles.

1 We frequently find, and I have myself seen, trunks of trees buried in sand, and converted into jet, the combustion of which exhaled an odour eminently sulphureous.

I found, in the accumulations of earth formed by the river Ceze, near Bagnols, in the department of Gard, a wooden shovel, entirely carbonized and loaded with pyrites.

2. It appears that the decomposition of

animal and vegetable substances occasions the formation of sulphur.

In 1778, when the bulwarks of the gate St. Antoine, at Paris, were dug under, there were found, at the foundations of the parapets, in the midst of the heaps of rubbish, formed by the filth brought thither from every quarter, very considerable quantities of sulphur.

It is well known that silver, exposed to the effluvia or emanations of animal substances, soon becomes black and sulphurized.

M. Proust observed, that at the approach of certain severe maladies with which he was attacked, all the silver money or trinkets which he chanced to carry about him were changed in this manner.

Stuffs impregnated with animal exhalations, when they have been heaped together for a long time, and then exposed to the air, diffuse a very sensible sulphureous odour.

We are therefore inclined to believe that sulphur is formed; but we will hazard no hypothesis respecting its formation, leaving to time and the progress of chemistry to develope this secret. We shall confine ourselves here to describing the processes by which it is ex-

tracted and prepared for the uses of commerce.

We have already observed, that sulphur mineralizes almost all the metals; it even sometimes happens, that when the metal is not very abundant in the ore, the extraction of the sulphur adds to the value of the produce, and renders the working of it advantageous.

Several processes are known by which sulphur may be extracted from metallic sulphurets: distillation in closed vessels is one of these means; and the following is the method used at Schwartzemberg, in Saxony, and at Alten-Sattel, in Bohemia. Tubes of earth are disposed in a gallery; the tubes have two openings: they become gradually narrower, and are slightly inclined towards one extremity, which opens into a receiver. These tubes are filled with pyrites broken into pieces, and they are prevented from falling into the receiver by means of a piece of baked earth, in the form of a star, placed at the end next the receiver; the other end is exactly closed, and a moderate fire is made, to cause the sulphur to flow into the receiver. This operation lasts eight hours.

The pyrites, deprived of a part of their sulphur, are used afterwards to make vitriol. In that state they are denominated *burnings of sulphur.*

This sulphur is purified by distillation, with a gentle fire, in iron cucurbits, with earthen heads, which open into receivers of the same material.

When the sulphur is contained in a less quantity in a mineral, and it is necessary to separate it from it by roasting or torrefaction, means have been found to obtain the greatest part of it by employing a process equally simple and cheap. This process is used at Ramelsberg, in the country of Hartz, where a lead mine is worked; and I have seen it practised at Saint-Bel, near Lyons, at a copper mine.

A square bed, or layer of wood, is formed, the sides of which are from 30 to 36 feet in length, on a dry soil: afterwards, a pyramid of broken mineral is raised upon this layer, to the height of 12 or 15 feet. This pyramid is truncated above, and a chimney or channel is formed in its centre, to facilitate the admission of air necessary for the combustion of the layer

of wood on which it rests. The sides and top are covered with the small pieces and dust of the ore: wet earth and moistened ashes are also used for this purpose, in order to concentrate the heat and prevent the loss of the sulphur.

As soon as the pyramid is thus arranged, burning coals, or red hot scoria from the smelting furnace, are thrown down the chimney, the layer of wood takes fire, the heat communicates to the whole mass, and after some hours it is sufficiently strong to volatilize the sulphur. Some holes are then made in the bed of mineral, in the upper part of the pile; the intervals are well covered with clay, and the sulphur, which cannot escape but through these cavities, condenses on their sides, and is taken out with a ladle two or three times in the day.

This process, which is very simple and cheap, was discovered in 1570, by Christopher Saunders. It may not only be applied to all the sulphureous ores which are worked, but it likewise furnishes a means to derive advantages from those pyrites which are neglected, as not sufficiently rich in metal.

Besides the sulphur which exists in ores, we find it abundantly in all those places which have suffered the action of subterranean fires. The decomposition of the pyrites, which produces more or less heat, volatilizes a part of it in its natural state, while the other becomes the base of the sulphuric acid, or is dissolved in the hydrogen gas, and escapes in the state of *sulphuretted hydrogen gas*, or *hepatic gas*. The environs of Etna and Vesuvius are rich in these kinds of phenomena; and they furnish us with products sufficiently abundant in sulphur to permit the working of them. But the finest mine of this kind is that of Solfatara, near Pozzuoli, in Italy. Sulphur is there obtained by distillation of the earths and stones which are impregnated with it.

This operation is performed in pots of baked earth, containing each about twenty pints. The mouths and bottoms of these pots are of the same width, but their bellies, or middle parts, are wider. They are infixed in two walls of a gallery, in such a manner that their bellies overhang both withinside and without, and there is between the two ranges an interval of about 20 or 22 inches. Each pot has a

cover of baked earth; and above the whole is a vault, leaving only a small opening to the bottom of the furnace, to serve as a chimney.

Each range is composed of five pots, and each pot has, in its upper part, and on the outer side, a hole capable of admitting a tube of one inch ten lines in breadth, and fourteen inches in length. This tube communicates with a pot of the same size, having a round hole in its bottom, which suffers the sulphur to flow into a wooden tub, made in the shape of a reversed cone.

This sulphur is known, after this first operation, by the name of *raw sulphur*, and *stone sulphur*. It is distributed in this state in commerce, and is applied under this form to many uses.

But as it may be wished to have it purer, and in forms more convenient, it is made to undergo at Marseilles, and other places, the following operations.

1. It is melted with a gentle fire in iron cauldrons, which have covers to prevent its inflammation. It is continued in fusion until all its impurities are deposited, and then cast in wooden moulds, into the form of *rolls*, such as we receive it.

2. The operation for converting it into *flowers of brimstone,* is carried on in a square chamber, each side of which is about twenty feet. A cauldron of very thick cast iron, about two feet in diameter, is placed without, against the side of the chamber: this is built over with stone-work, and has within it two conduits or tubes, which open into the chamber—(The chimney of the furnace has no communication with the chamber, nor with the inside of the cauldron.)

This chamber has a small opening in its upper part, to let out the air dilated by the heat, and the little sulphureous acid which is formed.

Sulphur is put into the caldron, and it is maintained in fusion by a moderate heat. It sublimes in vapours, and deposits itself in the inside of the chamber, where it forms a pretty thick coat or layer before it is taken away.

When the fire is too violent, the sulphur passes into the state of soft sulphur.

This sulphur minutely divided and reduced into a fine and impalpable powder, is called *flowers of sulphur, sublimed sulphur.* It is a little acid, and yellower than the sulphur in rolls.

Sulphur, in its natural state, is applied to several uses, which may be mentioned here; of its combinations we shall speak elsewhere.

1. The property it has of burning with flame, causes it to be employed to determine combustion in other bodies less inflammable. For this purpose sulphur is melted, and the extremities of some very combustible bodies, such as small, long, and narrow pieces of very dry wood, the stalks of some vegetables, slips of strong paper, or of cards, &c. are dipped into it. These substances carry away a portion of the sulphur, which soon fixes, and inflames when presented to ignited charcoal, or any other body moderately hot. The heat, increasing by the combustion of the sulphur, inflames the body to which it is applied; and by the application of the latter to other combustibles, inflammation is completely produced. In this consists the art of the preparation, and the use of *matches*.

2. As sulphur, when properly melted, takes the polish of the surface upon which it is run, modellers make moulds of it, and take, by this means, very fine impressions of medals, and engraved stones.

3. Sulphur has been, at all times, used with much success in medicine, as a resolutive, sudorific, and tonic. Cattle are fattened by having a small quantity of sulphur mixed with their food. Antonio de Herrera relates a fact with respect to this subject, which deserves to be known. He says that the province of Quatimala is a prey to subterranean fires, and that it was at the mouths of the caverns whence the sulphureous vapours exhale, that the conquerors of Mexico gathered the sulphur which they used to make the first gunpowder America produced. He adds, that there are in that province lakes which have their source in these sulphureous soils; that the waters take up a great quantity of the sulphureous matters, and throw them in abundance on their banks; and that the pastures watered by them, fatten the animals which feed in them, so that the leanest horses will acquire, in a very short time, an extraordinary plumpness.

4. Sulphur has been much used in our time, to fasten iron in stone; but as, in this case, it combines with the metal which it dissolves, it forms with a pyrites, which effloresces and becomes vitriolized by the action of the air and

water, and soon causes the destruction of the iron, and of the brightness of the stone.

5. The vapour of sulphur, likewise, is used to whiten silk. Sulphur enters into the composition of gunpowder and oil of vitriol. We shall have occasion to treat on all these subjects when we speak of its combinations.

II. *Of Phosphorus.*

Phosphorus is a combustible substance, which inflames at the lowest temperature, and burns with a most lively flame, producing a very strong heat.

This singular substance was discovered about the middle of the seventeenth century. Kraff published the process for making it in 1689, and Homberg in 1692. This process, long, difficult, and dangerous, was superseded in 1743, by that of Margraaf; and the latter was followed till about the middle of the last century, when Gahn and Scheele demonstrated the existence of phosphoric acid in bones, and taught the method of extracting the phosphorus.

But whether phosphorus be obtained from urine by the processes of Homberg and Margraaf, or extracted from bones by the method of Scheele, the product is always of the same nature.

By degrees, the means of extracting phosphorus were simplified; and its existence was successively discovered in stones, ores, animal and vegetable matters; so that this substance, which at first might be considered as a production merely curious, appears to act a great part among the productions of our globe.

Phosphorus has the consistence and demi-transparence of wax; it may be easily cut with a knife; it softens and flows liquid in warm water; it shines in the dark; it inflames at 20 or 25 degrees of heat, of Reaumur's scale; it diffuses a lively light, and produces a white image; when rubbed against any hard body, it leaves traces of light, which preserve the characters or figures that may have been drawn; it dissolves in azote, according to the interesting observation of M. Berthollet; the white smoke which it suffers to escape in the atmosphere, has a very distinct odour of garlic

Of all the known processes for procuring of

phosphorus, I shall describe only that which has constantly best succeeded.

Bones are calcined in such a manner, that the outside becomes white, while the inside remains black: they are carefully pulverized, and the powder put into an earthen vessel moistened with a little water. Four parts of sulphuric acid are then poured on six parts of the pulverized bones, taking care to stir the mixture continually while making it. The whole is then diluted, when it is cold, in forty parts of water: it is filtered, and the residue pressed to extract all the liquid.

The residue thus expressed, is mixed with a quantity of warm water equal to the former.

These lees are evaporated to dryness in a copper basin. During the operation is precipitated selenite, or sulphate of lime, which is separated by the filter. The only residue obtained is a thick matter, which is mixed with charcoal-dust till the mixture becomes friable: it is dried till the bottom of the basin is brought to a red heat.

This substance is pounded, and put into a porcelain retort that is luted, and to which a receiver is adapted, into which water is put in

such a manner, that the beak of the retort is in part plunged into the water. Distillation is then proceeded to in the ordinary manner, and the heat is increased till the phosphorus flows through the beak of the retort.

The distillation of phosphorus is always accompanied with the production of a considerable quantity of phosphorus, hydrogen, and much carbonic acid, which escape from the apparatus. A great part of the phosphorus rises in vapours, and is condensed on the surface of the water, where it forms a coat more or less thick : that which flows in drops is precipitated in the water, and falls to the bottom.

When the operation is finished, all the products are mixed together, and put in a moistened bag of chamois leather, which is plunged into warm water, and when the phosphorus is melted, it is pressed with the hand under the leather, to make it pass through the pores of the leather, and purify it. This operation gives to the phosphorus that semi transparence, and that tinge of wax, which it has but partially after the distillation.

To mould phosphorus into small cylinders, it is cut into little pieces, which are put into

small cylinders filled with water, and of which the two orifices are stopped with pieces of cork. The tube is immediately plunged into boiling water: the phosphorus soon melts, and afterwards the tube is put into cold water, to fix the phosphorus When it is wished to extract the phosphorus from the mould, the cork is taken out, and the extremity pressed with a hard body, to make the stick of phosphorus come out at the other end.

The facility with which phosphorus inflames, the rapidity with which it burns, and the intensity of the heat which it developes, render all these manipulations dangerous, and they require much caution. Phosphorus is most carefully preserved in water: it ought to be handled but little, and moistened at intervals.

The theory of the operation we have described, to extract phosphorus from bones, is not difficult to deduce. The phosphate of lime is decomposed by the sulphuric acid, which is employed in the process; the phosphoric acid is set free, and by mixing it with charcoal, in order to subject it to the action of a violent heat, the decomposition is effected. The oxygen unites to the charcoal, while the phosphorus is collected in the receiver.

If, instead of stopping the evaporation of the lees of the bones, they are subjected to a stronger heat in a crucible, it puffs up considerably, letting out bubbles which inflame; but some time afterwards it subsides, and there remains in the crucible only a vitreous very transparent mass, of a specific gravity of from 3 to 1. This is what is called *animal glass.* It remains dry and inalterable in the air. Human bones afforded me a quarter of their weight of this matter.

The manner of converting bones into glass, was known to Becher. *Homo vitrum est, et in vitrum redigi potest, sicut et omnia animalia.** He regrets that the Scythians who drank out of disgusting skulls, should not have known the art of vitrifying them. This glass is sometimes very white and milky; *colorem lacteum narcissuli referens,* adds Becher; but it appears that, in this case, the lime which is found in the bones, and which we reduce into a sulphate in our process, has not been separated. This glass has the colour of the turquoise, when the operation is performed in copper.

* Man is glass, and may be reduced into glass, as may all animals.

This glass, when cut, has a beautiful water, and almost the brilliancy of the diamond. Pulverized and distilled with half its weight of charcoal, it becomes decomposed, and produces phosphorus.

For a long time phosphorus was only an object of mere curiosity, and, besides the difficulty of preparing it, did not suffer a hope to be entertained that it could ever be applied to ordinary uses. But at present, that the process has been simplified, and it has been introduced into commerce at a price sufficiently moderate, advantage begins to be derived from the facility with which it takes fire, to make of it what are called *phosphoric matches, philosophical tinder-boxes,* and *eudiometers.*

III. *Of Carbon.*

The charcoal used in our furnaces is not pure; it contains a great quantity of hydrogen, which is almost inseparable from it, and some earthy, alkaline, and metallic principles. It is to charcoal deprived of all these principles, that the name of *carbon* has been given.

Carbon exists in all the great classes of the productions of nature. It forms the basis of vegetables, of which it is the most abundant principle, and of which it constitutes the frame or skeleton; it is one of the elements of animal substances, and is found in the mineral kingdom in combination with iron, as in plumbago.

There is a great difference between the manner in which carbon exists in vegetables, and in animals. It constitutes the frame, and makes the strength and support of the former, while, in the latter, it is to the phosphate of lime that solidity is to be ascribed; the soft parts appear to be more rich in carbon than the hard.

To obtain *carbon*, it is only necessary to distil substances that are provided with it. The heat successively separates the water, the oils, and the hydrogen, in part; and there remains in the distillatory vessel, a black matter, which preserves the form of the vegetable on which the operation has been performed, or which presents a spongy light mass, when the soft parts, whether vegetable or animal, are distilled.

All the operations known for *carbonization*,

may be reduced to a distillation little varied in its processes.

In our laboratories, and in some manufactories, where it is wished to obtain separately, and with exactness, the carbon, and the volatile products which escape by distillation; the retort is two large cylinders of iron, into which are put the substances intended to be charred.

The art of charring of wood, as it is practised in the midst of the forests, to produce charcoal for general use, presents us with the apparatus and all the phenomena of a true distillation.

Pliny says, that the wood was piled in a pyramid, that the surfaces of the pile were covered with clay, and that, after it had been set fire to, the smoke was let out by an opening formed in the upper part.

This short account is sufficient to shew that the process used in our time, differs but little from that which this great naturalist has described. In fact, almost every where wood is piled up against a pole fixed perpendicularly in the ground. The dryest and smallest wood is placed at the foot, and holes are made at the base, to conduct the currents which terminate

at the perpendicular chimney, formed in the midst. When the pile is constructed, the surfaces are covered with moistened earth, or with solid turfs, and no part is left open but the apertures by which the air is to come in and go out. The leaves and dry wood, which have been put in the holes, are to be kindled. The fire is maintained by the current of air passing through the holes to the chimney. The heat is communicated to the whole mass, and a thick smoke escapes at the summit. The fire is maintained during ten, fifteen, or twenty hours. But when the smoke diminishes, and becomes acrid, and the summit is sensibly depressed, the manager throws burning charcoal into the chimney. He afterwards stops all the apertures with care, to concentrate the heat, and he uncovers successively some points of the surface, to attract the heat, and char the wood which is not sufficiently changed. He judges that the operation is equal at every point, when the sinking down is general, and the smoke ceases every where.

As soon as the smoke has ceased, and the earth of the covering appears red in the dark, all the holes are stopped, and a new bed of

earth is laid over the covering, completely to stifle the combustion, and extinguish the little charcoal which might be burning.

It is still the practice to char in ditches, all the wood intended to furnish charcoal for the composition of gunpowder. For this purpose, a pit is dug in a dry place, of about seven or eight feet in dimensions on each side; the sides are lined with brick, and wood is burned in it till it is entirely filled with charcoal. It is then covered with a wetted covering, over which a layer of earth is laid as speedily as possible, and trodden down with the feet, that there may remain no vacancy between the covering and the burning charcoal.

Some days afterwards the covering is taken off, and the pit emptied.

Care is taken to strip the bark off the branches or shoots that are to be charred, and those only are used that are at least two, but not more than three years old.

Hard wood is preferred for making charcoal; branches from one to three inches in diameter, are only used for this purpose; the young and old trunks are rejected.

The loss which the wood sustains by this

operation is from one third to five sixths of its weight, according to its quality.

Good charcoal is sonorous and brilliant; it breaks sharp, presenting a smooth fracture.

Light woods produce a porous charcoal, which sparkles when it is ignited, and which is soon converted into ashes: hard woods, on the contrary, give a charcoal, the combustion of which is gentle, and the decomposition very slow.

Charcoal imbibes, with great facility, the humidity of the air. Its weight frequently increases by one fifth in a very short time. This is one of the causes of the great difference between charcoal newly made and old charcoal. It has been proved in our time, that the using of charcoal in these different states, altered the quality of gunpowder in a surprising manner.

Charcoal likewise contains within it another cause of deterioration; it effloresces in the air, and is reduced to a powder. This originates in the existence of a little lime, and some atoms of potash, which pass into the state of carbonate. Hard charcoal is less subject to this al-

teration, than that which is made with the white woods.

The manner of charring wood has likewise an influence on the quality of the charcoal: if, for example, the wood be *baked* in a pit, as it is when charcoal is made, intended for the composition of gunpowder, the same wood affords a lighter and less hard charcoal.

The different parts of the same vegetable produce charcoal of different qualities. The ligneous part gives the best; that of the bark is of a bad quality; as is that of the suckers, leaves, and fruit.

Thus the nature of the vegetables, their age, their exposure, the climate, the different parts of the same vegetable, the season of the year when it was cut; all these causes contribute powerfully to vary the qualities of charcoal; and we ought, therefore, to be the less surprised at the great difference which is observed in its effects, whether in our common use of it, or in its important combinations with iron for the fabrication of steel

The decomposition of vegetables buried in the earth, presents us with phenomena that have some relation to carbonization. The

water which has filtrated through their texture, has extracted from it all the juices, salts, and, in general, all the soluble principles, in such a manner that there remains only a thick oil, and a black fibrous texture.

Travellers agree that, in all the accumulations of earth formed by great rivers, whole trees are found entirely converted into charcoal.

The *suturbrand* of the Icelanders is a real charcoal; the woods from which it derives its origin, having been covered by burning lava, and having undergone an actual distillation.

The formation of a kind of turf, which is found in beds or layers on the banks of many rivers, has, in like manner, for its principal cause the decomposition of buried vegetables: that which is dug on the banks of lakes or marshes, appears to have no other origin; nor does that which is found in the accumulations of rivers, or in the low grounds and flats, which, in very remote times, were the beds of marshes or ponds.

The charcoal of which we have been speaking, and which is produced by the decomposition of vegetables in the earth, is still less near the state of carbon than that which is ob-

tained from the same substances by distillation. It contains a thick vegetable oil, which may be separated from it by an operation analagous to the carbonization of wood; and pit-coal, thus purified, is called *coak*, and is preferred in all cases in which a lively, concentrated, and continued heat is required.

Charcoal is perhaps the most fixed of all bodies in nature: the most violent heat can neither sublime nor decompose it in close vessels; it only disengages a great portion of its hydrogen, and brings it nearer the state of carbon.

By carefully lixiviating charcoal strongly calcined, with a water feebly sharpened with the nitrous acid, we separate from it some earthy and metallic principles; and by making it a second time undergo the action of a very brisk fire, we obtain a charcoal very near to the state of carbon.

M Proust has already observed, that concentrated nitric acid, poured on charcoal reduced to a very dry powder, decomposed on it sometimes with inflammation; and I have found that, if the action of a nitric acid, too feeble to produce inflammation, be assisted by heat, the charcoal dissolves, the acid turns red,

thickens, contracts a bitter and disagreeable taste, and at length inflames, if evaporated to dryness. Mr. Hatchett has shewn, that, in this case, tannin is produced; and has proved its chemical properties, and its effect on skins.

Rouelle had ascertained that alkalies dissolved carbon; and this is a fact to which the operations in our manufactories bear witness every day; for when a soda of a bad quality, like that gathered between Aigues-Mortes and Frontignan, is dissolved in water, the carbon may be precipitated in a very clear solution, by saturating the alkali with sulphuric acid.

Hydrogen and oxygen in like manner dissolve carbon; and it is by the aid of these solvents that it circulates, and passes from one body into another. I have had opportunities of observing, in my operations on the juices of some succulent plants, an account of which is inserted in the Memoirs of the Institute, that oils, extracts, and resins, besides the portion of carbon which is one of their constituent principles, hold likewise in dissolution a certain quantity of carbon, of which they favour the circulation in the vegetable, and which may be precipitated from them by heat, oxygen,

the sulphuric acid, sometimes even by alcohol, when it is dissolved in an oil or a resin. The former experiments have been confirmed by the process which has been discovered for purifying and clarifying oil of colza, and which consists in mixing the oil with about one hundred and twenty-fifth part of sulphuric acid. The colour of the mixture becomes green, and it gradually clears itself by the deposit which it forms on the sides of the vessel, of a thick coat of a black and carbonaceous matter. In this case, the acid which has affinity with the oil, precipitates from it the carbon.

From what has been said, the nature of the growth of a vegetable will be easily understood: the carbon circulates in the plant by the aid of the solvents of which we have spoken, and is precipitated by heat or oxygen, to serve as nourishment to the vegetable. The phenomena and causes must be the same in the nutrition and growth of an animal.

In our time it has also been discovered, that carbon has the property of absorbing the offensive odour which is disengaged from animal matters in a state of putrefaction, and from fetid waters. It has also been used with suc-

cess to take from brandy the fiery taste it contracts by distillation. M. Cadet Devaux, by boiling over a slow fire twenty-four pounds of molasses, as much water, and six pounds of charcoal, and evaporating it, after having continued it boiling during half an hour, and then strained the liquor, succeeded in sweetening molasses so as to use it as sugar. By the same process, the particular taste which honey has may be taken from it.

M. Berthollett has likewise shewn us that, by carbonizing the inside of casks, water may be preserved in them during a long time, without contracting any bad smell; and this has been confirmed by navigators, who have tried the experiment in long voyages.

It is to the same principle that we must refer the practice, which is very general, of carbonizing the ends of poles which it is intended to fix in the ground: they are by this means preserved from putrefaction.

I have also observed, that when old chesnut-trees, or other trees, are rotted withinside the trunk, and threatened with speedy destruction by the progress of this putridity, it may be remedied by applying fire to the decayed part, and carbonizing all the surfaces.

But the greatest use of wood-charcoal is for our domestic fires, and those of our manufactories of every kind. Its consumption in these is enormous, and it is preferred to all known combustibles, for the facility with which it furnishes a heat that is constant and lively, and easily increased or diminished at pleasure.

SECTION II.

Of Compound Combustible Substances.

We comprehend under this title, oils, bitumens, resins, &c. and all bodies, whether vegetable or animal, which are eminently composed of hydrogen and carbon united to other principles, which vary their properties.

I. *Of Oils.*

It has been agreed to give the name of *oils* to bodies that are fat, unctuous to the touch, more or less fluid, insoluble in water, combustible, and forming soaps with alkalies.

Oily matter appears to appertain essentially to organic substances, and may be considered as one of the most simple and most common products of vegetation and animalisation. It exists in all seeds, and circulates in the vegetable by favour of the mucilage which renders it soluble.

Oils have more or less fixedness; they burn with more or less facility, and have been long distinguished into *fat oils* and *essential oils*. The authors of the new Chemical Nomenclature, have divided them into *fixed oils* and *volatile oils*.

The difference which exists between these two kinds of oils, resides not only in their different degrees of fixity, but in the manner in which they act with the re-agents Fixed oils are insoluble in alcohol; the volatile dissolve in it. Fixed oils have, in general, neither smell nor taste; the volatile are acrid, caustic, and very odorous Fixed oils, besides, burn with less facility than the volatile; and if we consult the results of analysis, we shall find that carbon is more abundant in the fixed, in which it exists with hydrogen in the proportion of 71 to 21, according to Lavoisier.

We may form a tolerably accurate idea of the modifications which may produce changes in the proportions between the carbon and hydrogen in oily bodies, by observing what takes place in the distillation of a plant. First passes a thin volatile colourless oil; soon after succeeds a heavier and higher coloured oil; and towards the end of the operation we see distil a black and unctuous one, which fixes as it falls into the receiver. The first product contains a little carbon, and much hydrogen: it is light, inflammable, and limpid. But as the distillation continues, the proportion of the hydrogen diminishes, and that of the carbon augments: the product thickens, becomes more and more coloured, less combustible, and more heavy.

These results may even be obtained by distilling a fixed oil; which proves that hydrogen allied to carbon gives products, which vary in a surprising manner, according to the proportions in which these two constituent principles are found united.

The combustion of volatile oils is generally attended with much smoke, because the heat necessary to maintain it being extremely feeble, it is insufficient to burn the carbon.

Of Fixed Oils.

Fixed oils almost all fix at different degrees of cold. There are even some which in the temperature of our climate have constantly a solid consistence; such are wax, butter of cacao, &c.; while there are others, as oil of nuts, for example, which do not freeze in the most rigorous cold of our atmosphere.

Fixed oils have a very marked unctuosity; they neither dissolve in water nor in alcohol; they volatilize at a degree of heat above that of boiling water; and take fire at a heat capable of reducing them into vapour.

In general fixed oils are contained in nuts, kernels, and fruits. They are almost always combined with the mucilage which they carry with them, in part, when they are extracted by pressure.

The most usual method of extracting fixed oil, consists only in applying a very strong pressure to the fruit containing it, to cause it to flow out.

But to render the extraction of it more easy, recourse is sometimes had to certain

accessary means, some of which have a sufficiently immediate relation to chemistry to claim a place here.

1. The fruit from which the oil is to be extracted is bruised and pressed in bags: this preliminary operation breaks the little cells in which the oily principle is contained, and presents them, as it were, open to the action of the press.

The oil which flows by the first pressure is usually the purest, and is called *virgin oil.*

The husks are sprinkled with boiling water, and, by the effect of this liquid, not only the oil is rendered more fluid and more readily flowing, but the mucuous matter which the oil carries off with it in the state of a mixture, or combination almost saponaceous, is dissolved.

Oil carried out, by the means of water, with the mucilage, is separated, in part, from the latter, which remains in flakes, or in solution, in the liquid.

There are countries, in which it is usual to collect in heaps the fruits from which it is intended to obtain oil, and allow them to heat and ferment before they are subjected to the action of the press. By this means the

oil combines better with the mucilage; and it is supposed that more oil is extracted, because a more abundant produce is obtained; but the quality of it is necessarily inferior, on account of the foreign principles which are united with it. This process has, however, the advantage of rendering the extraction more perfect, as the texture of the fruit being more softened, the pressure becomes more efficacious, and the extraction more easy and complete.

Several writers have decidedly condemned this method of extracting oils: they only considered the alteration which the oil underwent by this preliminary fomentation, and did not reflect that very often it may turn to the profit of the proprietor or farmer to sacrifice every thing to increase the quantity. Besides, the use of oils is not exclusively for our tables; they are employed by dyers, and in soap and cloth manufactories, and it is in these establishments especially that they have their great consumption; and for these pure oil is less proper than that which is obtained by the process that has been described. The perfection of any art consists entirely in the means

of accommodating the fabrication to the uses to which the products are applied in commerce.

3. As the water which is mixed with the paste, to extract from it the oil with more facility, inclines it to become sooner rancid, its effect is produced without it, in all cases when the oil is very abundant in the seed, by the means of heated plates, between which the matter reduced to a paste is pressed. It is in this manner that oil of sweet almonds is extracted.

4. When the mucilage is too abundant in an oily seed, pressure alone will not be sufficient to separate from it the oil, which will remain as it were lost in the mass of the parenchyma. In this case the seed is torrefied, by which means a part of the mucilage is dried and burned, and then the oil, which always preserves the same fluidity, flows under the press without carrying with it the mucous principle. It is in this manner that linseed oil, and the oils of hen-bane, poppy, &c. are extracted *.

* I have always thought that this method of fixing the mucous principle by drying, or, if I may use the expression,

In general, the oil which flows by the first action of the press is more pure and more liquid than that which passes towards the end of the operation: the proportion of the mucilage is the greater, the stronger the pressure. A great part is precipitated by the oil being merely left at rest, but there still will remain a part in combination. The deposit which oils form in time presents only a mixture of mucilage and fibre; and the method of purifying and clarifying oils, would be merely to keep them a long time in very clean vessels, did not

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carbonizing it, might be applied advantageously in many operations relative not only to the extraction of oils, but also to the fermentation of vegetables. I have observed, for example, that the greater part of plants, which in hot climates furnish by fermentation certain products, which they do not give in colder climates, may be rendered capable of producing the same effects, by previously torrefying the mucous principle, which is more abundant in the vegetables of the north than in those of the south, and which in the former produces a putrid fermentation. Proceeding on these principles, we might fabricate almost every where matters useful for colouring and dyeing, which are extracted by the fermentation of certain vegetables; and we might add infinitely to these methods of preparation, by varying and managing at pleasure the fermentation.

the time necessary occasion a loss to the proprietor.

This latter consideration has induced persons engaged in commerce, and chemists, to endeavour to discover some more speedy methods for clarifying oils.

In Holland, they take an earthen pot, well glazed, into which they put one-third of fine sand, and one-third of water, with the linseed-oil they wish to whiten. After having covered the vessel with a glass cover, they expose it to the sun, taking care to stir it at least once a day. When the oil has become very white, it is left at rest during two days, after which it is taken away for use.

At Paris, oil of colza is purified and whitened for the use of the lamps, with a current of air, by the aid of sulphuric acid. For this purpose, four drams of sulphuric acid is put into an earthen vessel, on which is speedily poured two pounds of oil of colza, which is naturally yellow and very thick. The mixture is carefully shaken: the oil becomes green, and after some moments of rest, fragments of carbon are seen to separate from it, and form a deposit on the sides. The green colour then disappears, and the oil

becomes white and limpid. After some days it may be used, decanting it with care. If it still retains a little of the yellow colour, the operation may be repeated, using a less proportion of the acid.

In this operation, the blue colour of the carbon, which precipitates, and the yellow of the oil, produce the green colour, which the mixture assumes immediately after it is formed.

Oil becomes the finer and clearer, the longer time it is left to settle.

A little water may be mixed with the oil, and the mixture strongly beaten, to take up the small quantity of acid introduced into it; but if the mixture be not left to rest for a long time, that the oil may separate entirely from the water, the oil sparkles when burning.

Chalk or potash may likewise be used; but in the former case the sulphate, which precipitates very slowly, causes many inconveniences; and the alkali which is used in the second process renders the operation expensive.

The mere exposure to the air of limpid oils, such as those of nuts, linseed, and olive, is sufficient to whiten them. This effect is

likewise still more certainly produced, by exposing them to the air, covered with an extremely thin coat of very pure water.

Volatile oils, and animal oils, easily absorb oxygen, and thicken.

Fixed oils are subject to contract a taste of the fire which is called *rancidity*. It is sufficient to apply heat to them, to develope that strong odour and acrid savour which form the character of rancid oils. On this account, seeds which are torrefied, to extract the oil from them, always afford an oil more or less rancid. It appears that the principle of heat acts chiefly on the mucilaginous part of the oil. Virgin oil does not easily become rancid; while the grosser oils have always a rancidity, which appears to be inherent in them.

The mucilage, which exists more or less in all fixed oils, is a source of continual alteration.

There are fixed oils, to which the property of speedily concreting or drying may be given, by boiling with metallic oxides: those of nuts, linseed, and carnations, are of this kind. They are called *drying oils*, on account of this property.

The substances most usually employed to give them this property, are the oxide of lead, called *litharge*, plaister, and umber.

The process most used consists in taking a pound of oil, and half an ounce of litharge, with as much ceruse, umber, and plaister. The oil is boiled on these four drugs, over a gentle and equal fire, taking care to skim it from time to time. As soon as the scum begins to rarefy and become red, the fire is stopped, and the oil being left to rest, gradually settles and clarifies.

The two oxides of lead which are employed in this case, have less the advantage of thickening the oil, by oxygenizing it, than of being themselves dissolved in part, and thereby bringing it to a state approaching to that of some pharmaceutical unguents. I ascertained this solution of the oxide in oil by analysis, and it is to the more easy solution of the oxides of lead that we ought to ascribe the cause of their superiority, and the preference given to them in the arts.

Oils boiled on the oxide of mercury revivify the metal, and thicken; but they do not ac-

quire the properties which the oxides of lead give to them.

Oxides of iron also dissolve in oils, which prepared by their means become very shining, and give to the bodies to which they are applied a brilliancy comparable to that of a varnish.

The plaister employed to render an oil drying, seems to have no other advantage than that of absorbing all the water which may be contained in the oil, in proportion to the mucilaginous principle.

It appears that, in the operation of which we have been speaking, the oil divests itself of all the mucilage which is precipitated on the matters employed, and which combines with the lead. Earths are very proper to favour this precipitation of the mucilage, and under this point of view they may be considered here as concurring to the clarification.

Linseed-oil will dissolve a quarter of its weight of litharge: it then thickens merely by cooling, and assumes the colour and consistence of caoutchouc, or elastic gum: in this state, when applied with a brush to any body, it forms on it a coat of varnish impenetrable

to water, which will not scale off, has great flexibility, and may become of very great use in the arts. Linseed oil, prepared or thickened by this means, becomes elastic like caoutchouc, burns like that substance, and may supply its place in many cases.

Oils rendered drying by the means we have described, acquire the property of thickening by contact with the air, especially when applied to a body in thin coats. This effect may perhaps be owing to the absorption of the oxygen, which probably is favoured by the presence of the metallic oxide dissolved in the oil, which tends to regain the portion of oxygen of which it had been deprived by boiling with the oil.

Oils may be combined with metallic oxides by decomposing soap by solutions of metals. In this manner is prepared a soap of a green colour, with the sulphate of copper, and a soap of a deep brown, or yellowish colour, with sulphate of iron. M. Berthollet has made a series of very important experiments on combinations of this kind.

The oil procured from vegetables is employed to light up our habitations. The

combustion constant and continually equal, of a wick impregnated with oil, the clear light produced, the facility with which we manage at pleasure this effect, are phenomena which no longer excite our admiration, because we are habituated to them, but which will never cease to occupy the attention of the chemist and the natural philosopher.

The smoke that escapes from all combustible bodies which are of the nature of oils, is the greater in proportion as the heat produced by the combustion is less. Thus the lamps with a current of air, invented by M. Argand, by causing a stronger aspiration, and the passage of a very rapid current of air through the midst of a circular wick, must produce a perfect, lively, and speedy combustion, which will develope a great heat, give an extremely bright light, and consume those carbonaceous particles which would have escaped an ordinary combustion.

Of Volatile Oils.

Volatile oil contains more hydrogen and less carbon than fixed oil. It entirely dissolves in

alcohol, and preserves in dissolution the odour which characterizes it.

Fixed oils exist in general in fruits, and especially in seeds, kernels, and nuts.

Volatile oil appears not to appertain to, or exclusively affect any organ. Sometimes it is distributed throughout the whole plant, as in the Bohemian angelica; at other times it is found in the bark, as in the cinnamon. Balm, mint, and wormwood, have their oils in their stalks and leaves; elicampane, the iris of Florence, and the avens or bonnet, in the root. The oils of rosemary, thyme, and wild thyme, is found in the leaves and buds of the flowers; those of lavender and the rose in the calix; those of camomile, the citron, and the orange, in the petals. Several fruits contain them throughout their whole substance, as the pear and the juniper-berry. Oranges and citrons have theirs in the peel and the skin; and the oil of the seeds of umbelliferous plants, as anise, fennel, &c. is contained in vesicles, which are arranged in saliant lines, that may be perceived on their bark.

Volatile oils vary likewise in their colour: that of the rose is white; that of lavender,

yellowish; that of camomile, blue; that of parsley, green, &c.

Oils likewise differ in consistence; some are extremely fluid, as those of lavender, rosemary, and rue. Those of sassafras and cinnamon are thicker; and there are some which are constantly in a concrete state, at the temperature of the atmosphere, as those of the rose, parsley, and bonnet; while some fix with the slightest impression of cold as those of anise and fennel.

All volatile oils likewise have not the same gravity; there are some which are even heavier than water. Those of sassafras and cloves precipitate in that liquid.

The odour of a volatile oil is constantly that of the plant which furnishes it; but it is not the same with the savour; that of pepper is not acrid, and that of wormwood has no bitterness.

In general, volatile oils appear to appertain to hot climates and arid soils. It has been proved that the same plants, removed to a more northern climate, or a richer soil, no longer afford either volatile oil or give out odour; and experience daily teaches us, that a rainy season is adverse to the developement of volatile oils.

All the methods employed to extract volatile oils, may be reduced to two processes, *expression* and *distillation*.

1. When a volatile oil is by nature extremely fluid, and is contained in prominent and very distinct cells, it is sufficient to exercise a moderate pressure on the part of the plant which affords it, to effect its extraction. This is the case with the citron, the orange, and the bergamot pear; when they are bent or pressed under the finger, drops of oil will issue from every vesicle, which, if approached to an ignited body, will take fire; or will flow when placed on the surface of a polished body.

In Provence and in Italy, where oils are prepared for the purposes of commerce, the skins of the fruits are torn with rasps, and the product, which flows out, received in vessels: the parenchyma in time settles, and the oil clarifies itself.

If a piece of sugar be rubbed against these vesicles, it will imbibe oil, and form an *oleo-saccharum*, soluble in water, and very proper to aromatize liquors.

2. Distillation is generally employed to extract volatile oils. For this purpose, the plant

or fruit containing the oil, is put into the body of an alembic. A quantity of water sufficient to cover the plant is poured upon it, and the water is made to boil. The oil rises with the water, condenses in the worm, and flows into the vessel placed to receive it. This vessel, called the *Italian receiver*, has a large orifice, and a beak affixed to its lower part, and terminating three or four inches below the upper edge of the orifice. By this means the oil which flows, and which is lighter than the water that serves it for a vehicle, remains in the neck, while the excess of the water escapes by the beak. *See Plate* II. *Fig.* 4.

The water which passes in distillation is thick, and very odorous. It holds in dissolution a little oil, by the assistance of a little mucilage which is united with it. These waters are called *distilled waters*. Distillers take care to pour these waters again into the cucurbit, by which means they obtain a greater quantity of the product; besides that this water once saturated with oil, may serve as a vehicle, without dissolving any more of it.

There are oils so ready to fix, that all the produce of the distillation would be lost in the

windings of the worm, if they were distilled by the ordinary method: such are those of the rose, parsley, cummin, fennel, elicampane, &c. To prevent this inconvenience, either the worm is not used, or warm water is put into it, so that the oil may not be able to fix.

The heavy oil of cloves may be obtained by the distillation called *distillation per descensum;* which consists in applying the fire above, so that the product may flow and precipitate downwards. For this purpose, a glass with a stalk is covered with a linen cloth; the cloves, having been broken, are put into the cloth, over which is placed a plate of metal, and on the plate are thrown some burning coals. The oil liquefies by the heat, passes through the cloth, and flows to the bottom of the glass.

As the greater part of plants from which oils are extracted, contain but little, and there is only one season in the year proper for the extraction of oil, but little profit would be derived from conveying them to a distant manufactory, to subject them to distillation; the operation therefore is performed, as we may say, in the middle of the fields. In the south of France, when the season is favourable for

distillation, that is to say, about the end of the summer, those who employ themselves in this work, carry their alembic into the midst of the plants themselves: they fix it in a furnace, which they construct at a small expence, and they distil till they have exhausted the resources of the neighbourhood: they then remove their little apparatus to another place; but they do not fix it, till they have certified themselves that they shall find a good harvest, to give them employment for several days. In this manner are prepared the oils of thyme, lavender, rosemary, and spikenard.

There are plants which diffuse a very agreeable odour, and which yet furnish but little oil by distillation: the rose is of this kind; and *butter* or *otto* of roses is therefore very valuable.

Some experiments which I have attempted to make, to facilitate the extraction of these sorts of oils, have inclined me to believe that it is possible to obtain these oily principles by the means of lees feebly alkaline; but, at the same time, I thought I could perceive that the agreeable or particular odour of these oils was sensibly altered. This preparation still requires some researches, which we cannot hope to pro-

secute with success, but by operating on a large scale.

Volatile oils are very liable to be adulterated; and for this purpose, they are mixed with fat oils, with less valuable volatile oils, or with alcohol, &c.

They are known to be adulterated with fat oils—

1. By distillation; the volatile oils ascend at the heat of boiling water.

2. By making paper imbibe a small quantity of this mixture, and exposing it to a heat capable of volatilizing the volatile oil, without touching the fixed.

Volatile oils which have a very strong odour, as those of thyme and lavender, are frequently adulterated with oil of turpentine. It is sufficient to rub a drop between the hands, to develope the odour of the latter.

The lighter oils may be mixed with a little alcohol: the fraud is detected by pouring some drops upon water, which, in consequence, will become white.

Volatile oils thicken in the air, and absorb oxygen.

If thick oils are distilled, a volatile oil is ob-

tained, and a residue which has almost all the characters of resins.

Acids thicken these oils, when they are slowly decomposed over them; and they inflame them, if the decomposition be rapid. The nitric acid is the most proper to produce these phenomena: the other acids dissolve them, and form soaps with them.

Of Camphor.

Camphor resembles volatile oils in so many respects, that it cannot be more properly placed than immediately following them: like them, it has a strong smell and taste; it dissolves in alcohol, from which water precipitates it; it burns and evaporates without leaving any residue; it dissolves in the acids, and supplies a radical to the nitric acid, when it is decomposed over it.

Nature has placed camphor near to the volatile oils, and there are few of them which do not contain it: and, to occasion a precipitation of it, it is only required to preserve them a considerable time in corked bottles. The oil of

cloves deposits one quarter of its original weight.

M. Bouillon Lagrange, by distilling it with alumine, decomposes it into two substances, one of which passes into the recipient in the form of volatile oil, and the other, which remains mixed with the alumine, is carbon. He concluded, that camphor is a volatile oil, rendered concrete by carbon.

All the camphor hitherto met with in commerce, is extracted from a species of laurus which grows in China and Japan. Travellers assure us, that old trees contain it in such abundance, that, by cleaving them, large and very pure drops are found, which require no further rectification. It is by the distillation of different parts of the tree, and particularly the roots, that camphor is extracted: they are put with water into an iron retort; bands of rice-straw are placed in the head, a recipient is adapted, and the distillation commenced. One part of the camphor is attached to the straw, and the other passes into the receiver.

The Dutch purify camphor by sublimation, after having mixed with it one sixteenth part of quicklime. The camphor then assumes a

white semi-transparent colour, and a strong odour: it emits, in burning, a white tranquil flame, and leaves no residue. It dissolves in alcohol, without affecting its transparency.

The distillation of the roots of zedoary, thyme, rosemary, sage, &c affords camphor: and it has been remarked, that these plants produce much more when they are dry, than when in a fresh state. Thyme and peppermint, when dried slowly, yield it largely: these plants when fresh, furnish only volatile oil. M. Achard observed, that a mixture of oil of fennel with the acids, emits a very marked odour of camphor. The same chemist obtained crystals much resembling camphor, by the action of dilute nitric acid on oil of aniseed: he formed a similar precipitate, by pouring vegetable alkali into vinegar, saturated with volatile oil of lingwort.

M. Proust endeavoured to direct the industry of the Spaniards to an object connected with the interests of commerce, and furnished them with the means of extracting advantageously the camphor contained in the oils of rosemary, marjoram, sage, and lavender. These oils are manufactured in large quantities in Murcia;

and the evaporation of them in the open air, in proper vessels, continued during a month, at a temperature varying from 6 — 20 of Fahrenheit, to 10 + 0 — 52 of Fahrenheit, produced camphor in the following proportions:

Oil of Rosemary	$\frac{1}{16}$
Marjoram	$\frac{1}{9}$
Sage	$\frac{1}{7}$
Lavender	$\frac{1}{4}$

Oil of lavender yields its first product at the end of twenty hours; it is deposited in transverse laminæ, and at the temperature of 15 +0—65 Fahrenheit The first production appears at the end of twelve hours.

If camphor be dissolved in oil of lavender by the aid of a gentle heat, it is precipitated again by mere cooling, and attracts with it a portion of the natural camphor contained in the oil; whence M. Proust infers, that oil of lavender is saturated with camphor.

The oil of sage deposits its crystals later; but they present the same arrangement This oil leaves a residue of the consistence of syrup,

which requires to be pressed, in order to separate the deposited camphor.

The oil of marjoram yields the precipitation more slowly, and that of rosemary the slowest.

Camphor extracted from the oils, does not retain the odour of them.

M. Proust afterwards attempted to separate the oil by distillation, and by that method to precipitate the camphor: he put the oil into a cucurbit, and distilled in a vapour bath, at a low and equable heat: after having drawn off one third of the oil, he left the apparatus to cool during twelve hours; the camphor separated in crystals, which were collected by a skimming-ladle. Fresh oil was added to the remainder, which was again distilled in like manner. Three distillations are sufficient to deprive the oil of all its camphor: the first furnishes the half of it. It is necessary carefully to avoid carrying the heat to the degree of ebullition, or evaporating more than the third part of oil employed. In either case, a portion of the camphor would be volatilized.

Camphor, according to the observations of Romieu, crystallizes by sublimation, in six-sided pyramids.

It dissolves very readily in alcohol, forming what is sold under the name of *camphorated spirits of wine.* When the solvent is saturated with it, or when it is slowly precipitated from the solution, it forms crystals in six-sided laminæ, attached to a common thread or center. Camphor is not soluble in water; it nevertheless communicates to it a characteristic odour; and this liquid is capable of transmitting, although feebly, its virtues.

The acids dissolve it without any sensible change: its solution in the nitric forms the *oil of camphor.* It must however be remarked, that camphor, precipitated from these solutions by the alkalies, increases in weight and hardness, and becomes less inflammable. According to the experiments of Rosegarten, by a repeated distillation of nitric acid and camphor, an acid is obtained, crystallized in parallelopipeds, which possesses all the virtues of this class of salts. It is called *camphoric acid:* Rosegarten first discovered it, and M. Bouillon-Lagrange has completed the investigation, by a series of interesting facts.

Of Caoutchouc, or Elastic Gum.

Caoutchouc is one of those substances which cannot be ranked in any of the large classes, into which chemists have distributed all the productions of vegetation.

We are indebted to La Condamine for the first accurate accounts obtained of this substance, and of the tree which produces it: this academician informs us, that, according to Fresnau, engineer at Cayenne, the caoutchouc is a very large tree, in the bark of which incisions are made, and the juice which flows from them is received into vessels. It is applied in layers upon an earthen mould, and dried by the sun or fire: while it continues quite soft, any kind of figure may be traced upon it; and when dried, the mould is broken and the pieces are extracted.

The tree which yields the juice, is the *hævæa guianensis* of Doublet, or the *jatropha elastica* of Linnæus. M. Richard has ranked it in the class of the euphorbiæ.

An analysis made by M. Fourcroy, of a bottle of this juice sent to the Society of Agri-

culture, proved to him, 1. That the elastic gum is dissolved or suspended in a milky juice, from which the mere contact of the air detaches it; 2. That the absorption of oxygen is the principal cause of this separation; 3. That the colouring of the gum is owing to this oxidation; 4. That the elastic gum, which yields ammoniac in distillation, only does so in consequence of the azote which it contains; 5. That it resembles gluten, rather than oils or resins.

Several productions are found in nature, which nearly approach the elastic gum, without combining all its properties.

1. Dorthes has observed, that the species of *coccus* which are clothed with a down resembling small straws, have an unctuous covering very analogous to elastic gum.

2. There has been found in the lead mines of Derbyshire, a fossil bitumen which has all the characters of caoutchouc. Of this there are two kinds; one brown, shining, and in its fracture like resin; the other of a darker colour, soft, and elastic. M. Lametherie, who has analyzed it, obtained the same products from it as from elastic gum. *(Journal de Physique,* 1787.

The juices of the euphorbia of our climate *(euphorbia ciparissias)*, when expressed and exposed to the air in capsules, becomes covered with a pellicle, which may be handled without breaking, which burns like elastic gum, but which, when dried, does not preserve its elasticity (Memoir on the *Juices of Vegetables*, first volume of the first class of the National Institute)

4. Linseed oil rendered strongly drying by boiling over litharge, and applied in layers upon earthen pots, acquires the softness, elasticity, colour, and combustibility of the elastic gum.

Elastic gum exposed to the action of fire, becomes soft, swells in bubbles, and burns with a white regular flame. It is used in Cayenne to light their dwellings It is not soluble either in water or alcohol; but sulphuric ether, the drying oils, turpentine, &c. form solvents, which enable us readily to apply it upon bodies, on which it makes a most valuable varnish.

Macquer was the first who informed us that it was soluble in ether, and founded, upon this circumstance, the art of making elastic probes, by applying upon a mould of wax, layers of

the varnish, till they have acquired their requisite thickness.

This process appears to be of difficult execution, and of very uncertain success. Pelletier has observed, that, in order to facilitate and insure the solution, it is necessary to soften the elastic gum in boiling water, cut it in small pieces, and then soften it again: in this state it is very soluble in ether, even when cold.

Berniard, to whom we are indebted for some curious researches respecting the caoutchouc, has found that the nitric ether is a better solvent of it than the sulphuric.

If elastic gum be placed in contact with a volatile oil, such as that of turpentine, or even if it be exposed to the vapour only of this oil, it swells, softens, and assumes the consistence of paste. In this state we may spread it over the surface of paper, or apply a coating of it upon stuffs; but this varnish is difficult to dry.

The mixture of alcohol with oil of turpentine, forms a better solvent than the pure oil, in as much as the varnish dries more readily.

The drying oils dissolve elastic gum with the aid of heat. This is the method used at present, to apply upon cloths, and other objects,

a varnish of this substance. It is the method at once the most simple and most economic.

Elastic gum melts also in yellow wax, at a boiling heat. This varnish likewise may be conveniently applied upon cloth; but it is liable to the disadvantage of stiffening too quickly.

M. Fabroni informs us, that rock oil, after several distillations, is capable, when cold, of completely dissolving elastic gum, and preserves all its characters. *Letters of Giobert to M. Berthollet;* Turin, October 22, 1791.

M. Frossard of Virly softens the thongs of this gum in boiling water only, and brings them in contact upon a mould, in order that they may join or solder together, and obtains, by this simple method, all the forms he desires.

These varnishes possess the inestimable advantages of not cracking, and of bearing the handling of common uses, without breaking or scaling off: they are impervious to air, water, &c. and unaffected by alcohol, acids, &c.; and on every account, we ought to multiply the uses of them, and to convert them into a very extensive resource of industry.

II. *Of Bitumens.*

There exist in nature productions which appear to occupy the intermediate space between organized and unorganized substances; they connect, so to speak, one kingdom of nature with the other; such is the case with regard to the bitumens. They exist in the midst of the earths or of metals, and present themselves sometimes in strata so vast, that the boldest imagination scarcely dares to refer their origin to the decomposition of organic matter: observation no more witnesses such immense accumulations of combustible substances; and, under every point of view, the bitumens appear to compose a class of productions, the formation and origin of which are hidden from us.

Nevertheless, when we consider that all bitumens are inflammable, that they yield oil by distillation, that, generally, they exist only in earths of the second or third formation, that they often present the remains of shells of fish, of insects and plants, we cannot refuse to draw from these facts two very obvious consequences: the first, that the formation of bitumens

cannot be referred to the first period of our globe: the second, that the decomposition of vegetables has concurred to their formation. In fact, if our review commence with the actual state of our globe, it is difficult to admit the possibility of the formation of such immense strata of bitumen by the decomposition of vegetables; for the cause is evidently inferior to the vastness of the effect: but if we retrace in imagination, those earliest periods when the globe, little inhabited, presented almost every where, a surface covered with immense lakes or thick forests, such as we still see in those countries, the primitive state of which the hand of man has left yet unchanged; if we consider that the seas, in certain parts, are so covered with living vegetables, that vessels cannot force themselves a passage; if we observe, according to the testimony of all travellers, that the surface of the North Sea, towards Spitzberg, Greenland, and Nova Zembla, is covered with enormous quantities of wood, the kinds of which are found in neighbouring forests; we shall then raise our ideas to the magnitude of the subject: in effect, the vegetables, growing in the sea or floated by

the rivers, drawn by the currents, or long agitated by the waves, are at length cast, heaped, and accumulated on the shore; here strata of earth, or a deposit of mud, bury them; and here takes place the process of their decomposition.

In lakes, and on the borders of rivers, the same causes operate; but here they are limited, and their effect is in proportion. We find frequently in the alluvions which are their operation, deposits of turf, of jet, or of coal. It was these primitive lakes, such as we still observe almost wherever the cultivation of man has not yet encroached, which fed those vast rivers, the extent of whose beds still fills us with admiration. It was these primitive lakes, which having disappeared, for the most part, to unite themselves with the common reservoir, should seem to have left, in different parts of our globe, various kinds of deposits, the formation of which we generally attribute to a cause much more difficult to conceive and establish, to the successive dislodgements of the sea.

But the decomposition of these masses of vegetables could not present uniformly, and every where, the same kind of bitumen: the diffe-

rence of the vegetables must occasion differences in the products of their decomposition: the pulpous and oily parts do not suffer a like alteration with the fibrous substance of the plant: the leaves, the young shoots, the herbaceous plants, undergo a fermentation essentially different in its effects from that of the wood or trunk.

It is further consistent with the natural order of things, that these accumulated vegetables should form strata more or less thick; that these strata should be mixed with foreign matter; that some should be deposited under the water, and others above, and on the shore. These different states and different situations, have an essential influence upon the products; and it is by reflecting upon the combined action of these causes, that we shall be able to comprehend the very various magnitude of the strata, the purity of the bitumen, the mixture of earthy matters, the compactness of the masses, the different degrees of alteration in the vegetables, &c.

In commencing with these principles, it will further be easy to conceive of the presence of exotic plants in the beds of bitumen, which

are exp'ored in climates to which the plants are foreign: the bamboo and banana are found in the coal-mines near Alais; and M. Jussieu has discovered plants of the Indies in the coal of Fores.

There are bitumens in which we still discern the texture of the plant to which they owe their origin. According to M. Jars, two strata are worked at Beichlitz, the one bituminous and the other of fossil wood. The texture of the beech is visible in the jet of Bosrup, in Sweden. There has been found in Guelderland, a forest of pines buried under the sand, almost converted into bitumen. At four leagues from Montpellier, near to the village of Saint Jean-de-Cuculles, beds of coal are worked, in which the texture of wood is every where discernible, and which has precisely the fracture and brilliancy of jet. I have myself observed in the Gevaudan, trunks of the walnut-tree, laid bare by the current, and presenting all the characters of jet.

All the bitumens yield, in distillation, mucus, an acid in part liquid and in part concrete, and an oil, which gradually thickens and becomes black; and there remains in the retort a portion of carbon.

Of all the bitumens, coal and jet are those which furnish most carbon; they even yield ammonia. Amber yields much acid and little carbon. Rock oil is constantly in a liquid state.

The bitumens may therefore be regarded as a mixture of vegetable oils with more or less carbon, hardened by the re-action of different acids. By decomposing certain acids upon the fixed oils, we succeed in bringing them into a state very nearly approaching that of bitumen; which confirms the opinion that we have advanced.

The bitumens, therefore, occupy the same place with respect to fixed oils, as the *balsams* do with respect to the volatile: the bitumens and the balsams are oils rendered thick, or combined with an acid.

Of Coal.

Coal is the most widely diffused of all the bitumens: it exists in considerable strata in almost every point of the globe, and is become the combustible the most employed in our works, and for domestic purposes.

A quantity of bitumen so enormous, cannot proceed from the sublimation of vegetables which grow on our continents. Entire forests, which may be supposed to have been buried by the different revolutions of the globe, would present a cause still disproportioned to the magnitude of the effect; and further, the trunks of trees buried in the earth, would have passed into the state of jet, and would not present to us those strata of coal in which the vegetable texture is no longer distinguishable.

It is sufficiently proved that coal, in its origin, is submarine; and we may comprehend its formation, by reflecting that, independent of the numerous plants which the rivers float into the sea, they also grow abundantly in this enormous reservoir; and that all, borne away by the agitation of the waves, are amassed in strata, and are decomposed.

This decomposition of plants under water, cannot present the same phenomena as that which passes in the air: under water, the heat cannot be more than moderate. The vegetable texture is softened by the liquid in which it is immersed; the different substances which are soluble are naturally extracted, and after the

expiration of some time, the insoluble elements only remain, which are oil and carbon. I therefore regard coal as resulting from the decomposition of vegetables under water, which, of their constituent principles, only preserve the oil and the carbon, because these alone escape the solvent power of this liquid.

According to these ideas, it will not be surprising to find still in coal the texture of certain known vegetables, and to observe land plants confounded with the marine. Nor will it surprise us to meet with the impressions of shells and of fish, or even sometimes with beds of shells, interposed with those of bitumen, as I have observed at Dorsan, in the department of the Garo.

We also see by the nature of the mountains which inclose the coal, that its formation is submarine; for they all are either schistous, of sand-stone, or of lime-stone.

We sometimes observe that the schist is only impregnated with bitumen: it is sometimes susceptible of being cut, and presents a smooth fracture, and gives out, in burning, a white vivid flame, which is extinguished without having changed its form. A mineral of this

kind is found at Lavencas, near Milhaud, in the department of Aveyron.

The surface of the earth further presents, at many points, calcareous stones impregnated with bitumen, which imparts to them, in a greater or less degree, a blackness of colour.

I have had an opportunity of observing near Alais, in the neighbourhood of Saint Ambroix, and of Servas, over an extent of several leagues, the calcareous earth and rocks so much loaded with bitumen, that the sun caused it to exude in stalactites upon the inequalities of the rocks, where it sometimes formed into masses sufficient to interrupt the progress of the plough.

Coal is often found in sand-stone, and this will excite little astonishment, if we consider that these mountains owe their origin only to the sand washed into them by the rivers, and tossed upon the shore by the waves. The same progress, the same cause, may have formed strata of vegetables amongst strata of sand-stone.

Coal is almost always disposed in strata more or less thick: often, in the same mountain, several are found, separated from each other by strata of schist or of sandstone; it rarely oc-

curs that they are not parallel one to the other. It is also generally supposed, that the inferior strata are of better quality than the superior.

The earthy base of all species of coal, is commonly formed of a secondary schist, more or less pyritical.

The quality of the coal depends upon the proportion which it bears to the earthy principle with which it is found. When the schist preponderates, the coal is heavy, and leaves much residue after combustion: if, on the contrary, it be present in small quantity, the coal is light, unctuous, swells in burning, and is almost entirely consumed.

The pyrites is not always present in coal, in proportion to the schist; and it is this substance in particular which affects the good or bad quality of the coal. If the pyrites abound, the coal exhales, during combustion, a sulphureous odour: it breaks readily in the air; it heats, and sometimes kindles in the mines, or places where it is kept; and probably, to large assemblages of coal of this nature, ought we to attribute the fire of volcanoes, earthquakes, and other analogous phenomena. Observation continually offers to our notice, re-

sults which may aid us to form a conception of these grand and awful operations. At Cransac, in Aveyron, a mountain of bituminous and pyritical schist daily exerts its decomposing energy: the heat is very strong at the surface, and we owe it to the smallness of the cause, that we are spared the scene of a burning volcano in its neighbourhood. The product of the decomposition is an alumine of the greatest richness. At Roque Cremade, near Bedarieux, in the Hérault, I have seen a mountain of sandstone cleft to the extent of 600 yards, in consequence of the internal combustion of a mine of pyrites.

The pyritical coals are commonly distinguished by yellow veins, which transect them in different directions. When we are obliged to employ them in our works, it is injurious to the boilers, which the sulphur pyritizes and destroys in a short time. A combustible of this kind can only be employed to burn lime; and for this purpose it is the more advantageous, as it leaves a residue which even adds to the qualities of the lime.

The superior quality of coal is that in which the bituminous substance is most abundant and

most pure: this exhales no sulphurous vapours: it swells in bubbles, and the pieces melt one into the other in burning: it yields an unctuous smoke, which, far from being injurious, appears to furnish an excellent remedy for complaints in the chest. The celebrated Hoffman relates, that the diseases of the chest are not known in the villages of Germany, where this combustible only is used.

In order to prepare coal for certain uses in which the smoke would be dangerous, it is subjected to a process, which has very improperly been called *dissulphuretting*. This is an actual charring of the coal, an operation perfectly analagous in method and in result to that which is employed in charring wood. In the same manner as in the charring of wood, pyramids of coals are first piled and kindled in the centre; and when the heat has strongly penetrated the whole mass, the sides are covered with damped earth: from this instant, a portion of the oil and water are dissipated in smoke; and there only remains as residue a light spongy coal, which attracts in the air from 20 to 25 parts in a hundred of humidity, and which presents in tranquil combustion the

same appearances as charcoal. It gives out scarcely any flame, no smoke, but much heat, and lasts very long.

Coal is generally employed for the purposes of fuel: it is preferable to wood, in being more convenient for use, and in producing a more equable effect; but it is inferior on account of the smoke it produces, and the difficulty of using it in small quantities; it is further inferior, in that it destroys more rapidly the grates and vessels. The English have, nevertheless, adopted it for all purposes: they heat their dwellings with it, they employ it in their manufactures; and it is much to be wished that France would adopt the use of it to an equal extent, and take advantage of this combustible in order to recruit her exhausted forests.

Becher, in his work, published at Francfort in 1683, says, he had succeeded in adapting to common purposes the inferior kinds of turf of Holland and the inferior coal of England. He adds, that he had procured from it a tar superior to the Swedish; he even says he had made it known in England, and had shewn it to the king.

In Scotland, Lord Dundonald some time ago erected furnaces, in which the bitumen of coals is detached, and received in vapour in chambers, where the condensation is effected by means of a current of water producing a constant refrigeration at the top. This manufacture for several years supplied the English marine with the tar it required.

M. Faujas has established the same process at Paris, under the inspection of government, and obtained an equal success. It is only necessary to construct a conical furnace, in the sides of which small openings are made, to establish the draught of the air, and that has a chimney terminating in a chamber, which serves for a receiver, and on the bottom of which a certain quantity of water is admitted, to fix or condense the vapours; the furnace is filled with the coals intended for distillation, and they are kindled at the bottom; in proportion as the heat is communicated to the higher mass, the bitumen rises in vapours, which pass and condense in the chamber. The lateral openings are closed or extended, according as it may be necessary, to prevent the escape of the vapour through them, or to pro-

mote the combustion by establishing a current of air from without.

It appears that the coals most proper for this purpose, are such as are reputed the worst in the works.

Coals further yield ammoniac, which is dissolved in the water, and may easily be separated from the oil.

Naphtha, *petroleum*, *mineral pitch*, and *asphaltum*, are only slight modifications of the oil which abounds in coals.

It is easy to conceive, that in all the depositories of pyritous coal, where a decomposition arises, phenomena analagous to distillation must occur, as natural consequences of the heat which is in these cases disengaged: the oil rendered fluid, separates itself from the bitumen, exudes through the pyritous mass, and flows off. Sometimes the water which filters through these strata serves as a vehicle to the oil, as is observed in the spring of petroleum at Gabian, between Pezehas and Bedurieux, where the bituminous water flows at the foot of a mountain, the summit of which is volcanic: the neighbourhood presents several ruins of extinguished volcanoes; mines of coal

are worked at a league from this spring. In this instance, no one will refuse to admit, respecting the formation of petroleum, the theory which we have adopted.

The vicinities of volcanoes, the neighbourhoods which conceal mines of pyritous coal, every where present similar phenomena; and whatever name we may give to the bitumens which proceed from them, we can attritute to them only one common origin. Thus the *naphtha*, *petroleum*, *mineral pitch*, and *asphaltum*, in the eyes of the chemist, differ only in their modifications.

Sometimes bitumenous oils kindle as they rise out of the ground, and support a continual flame. Kempfer visited the springs of bitumen in the neighbourhood of Erbens, on the Caspian sea: he saw one whence a flame rises which is never extinguished. The Indians maintain that the Deity threw in the Devil, in order to deliver mankind of him; and they go out on pilgrimage to the spot, to pray the Eternal not to suffer the escape of this enemy of the human race. This perpetual fire is of great service to the inhabitants of Baka: they make bare the surface of a small circle of this

burning soil, and pile heaps of lime-stone mixed with the earth they have raised, and in two or three days the lime is burnt. The inhabitants of the village of Fragann resort thither to cook their food.

Mineral pitch is another modification of the petroleum. It is found in Auvergne: it is soft during the summer, and the inhabitants collect it in order to mark their flocks.

Asphaltum is of a more brilliant black; is more dry and fragible. It floats on the lake Asphaltites, or the Dead Sea. The asphaltum of commerce is drawn from the ruins of Annanore, and particularly from the territory of Neufchatel. Pallas found sources of it on the borders of the Sock, in Russia.

Of Amber.

Amber (karabé electum) is found in yellow or brown pieces, transparent or opaque, susceptible of polish, and electric by friction, &c. It is friable and brittle.

There is no substance on which writers have more exercised their imagination than on this.

Sophocles had already supposed it was formed in India, by the tears of the sisters of Meleager, changed into birds, and lamenting their brother. But one of the most pleasing fictions which has been conceived on this subject, is that which originates in the fable of Phæton setting on fire the heavens and the earth, and being precipitated by thunder into the waves of the Eridan; the sacred tears of his sisters fell into the waters without mixing with them, consolidated without losing their transparence, and were converted into the *yellow amber*, so highly valued by the ancients.

But setting apart these fabulous origins which have been assigned to amber, we are forced to consider it as a vegetable oil, indurated by the re-action of saline substances. The fragments of vegetables, the insects found imbedded in the pieces of amber, are all evidences of its having been fluid, and the acid which is extracted by distillation, must determine its rank among the bitumens.

Amber is often found dispersed in beds of pyritous earth, covered by a stratum of wood rendered bituminous. I have myself found a piece weighing nearly 7lb. incrusted by a grey

pyritous earth, in the forest of Leserelle, in Provence. The interior of this kind of wood is very pure amber, of a greyish colour. It has also been found near Sisteron.

When amber is distilled over an open fire, but at a gradual well regulated temperature, an acid aqueous liquid is first obtained; then a penetrating fluid oil, which becomes black and thick in progress of the distillation, and lastly an acid concrete salt, which sublimes in the neck of the retort.

The acid liquor which rises first in the distillation, holds in solution a portion of volatile salt and a small quantity of volatile oil. The name of spirit of amber has been given to the first of these products.

The concrete salt, diluted in water, possesses all the characters of acidity: it is purified by sublimation. This may also be effected by distilling it with sand, according to Scheffer; with alumine, according to Bergmann; and with the muriatic acid, according to Spielmann, &c. The same effect is further produced by detonating it with nitre, as recommended by Bourdelin; and by filtering it through cotton, according to the process of Pott.

The salt is prepared at Konigsberg in great quantities, where they distil the refuse wasted in working the yellow amber.

This acid has a sharp taste; it dissolves in the double of its weight of boiling water, and in twenty-four parts of cold water. It crystallizes in triangular prisms, the points of which are truncated.

Oil of amber is the whitest of all the bituminous oils, and that which has the least disagreeable odour. It is completely deprived of its colour by distilling with alumine, or simply with water, as is recommended by Rouelle.

The oil of amber forms, with ammonia, a soapy white liquor, which is called *eau de luce.* This preparation deposits a sediment after some time, and no longer possesses the agreeable colour which it at first presents. To obviate this inconvenience, I have proposed to dissolve the soap of wax in alcohol, with a little oil of amber, and to add a small quantity of ammonia. This combination, when once made, never decomposes.

Alcohol attacks amber and contracts a yellow colour. Hoffman forms this solution by digesting alcohol upon amber, triturated with

fixed alkali. This tincture of amber of Hoffmann's, does not become white by addition of water, and has therefore a characteristic of soap, which that does not possess which is made by the direct action of the alcohol upon the amber.

Amber is employed in the arts, in the manufacture of trinkets.

It appears that the ancients held this bitumen in higher estimation than we do, for almost all their ornaments were composed of it.

The property it has of being easily wrought, and of receiving a beautiful polish, has probably tended to multiply its uses.

In medicine it is employed in fumigation; and, in pharmacy, a syrup is composed of amber and opium, which has great virtues as a sedative.

Amber forms the base of the *fat varnish*. In order to dissolve it in linseed-oil, it is first roasted, by keeping it some time in fusion, which deprives it of a portion of its acid and a portion of its oil: it by this means becomes susceptible of solution in oils. Without this preparatory operation, the solution is very incomplete. This fat varnish is more solid than

any other, and capable of taking a beautiful polish.

Of Jet.

No naturalist has travelled who has not remarked the progress of the convertion of wood into jet. We find often, and in different parts of the globe, trunks of trees which have been buried, and have passed into the state of jet; and in almost all may be traced the distinctive characters of the species of tree to which they belong.

These decomposed trunks are more or less brittle, more or less unctuous, according to the species of the tree, the degree of alteration, and the nature of the soil: all have a smooth and glassy fracture, but are not all adapted for the tool of the workman. There are some even which are penetrated with pyrites, and which in a short time effloresces in the air; and on this account we cannot with equal advantage work the different beds of jet which are found scattered over the surface of the globe.

The decomposition of wood commences at

the exterior, and proceeds by degrees to the heart of the tree.

I have seen, and am still in possession of specimens of trees, the heart of which is in the ligneous state, and presents all the characters of wood, with the exception of the colour, which is become brown, while the exterior is formed of a coating of very brilliant and perfect jet.

When the texture of the tree presents only a mass of dry fibres, the jet obtained is dry and brittle, and cannot be used in forming the trinkets which are manufactured of this bitumen; but if the texture of the vegetable be unctuous and oily, the fibre acquires a softness, and the intimate combination of these two principles is susceptible of being wrought, and receives the most perfect polish.

It is this latter sort which is employed in several manufactories to make buttons, necklaces, boxes, &c. There is a manufactory of this kind in the neighbourhood of St. Colombe, three leagues from Castelnaudary. The bitumen is wrought by the lathe, and the polish is given to it by the wheels employed in forming it.

Of Resinous Substances.

All pines furnish a resinous juice, or turpentine, but all do not furnish it in equal quantities.

Among the different species of pine, the resin abounds most in the following:

Cypress pine. Pine of Canada, with three leaves.

Grey pine. Pine of Canada, with leaves and cone short and curved.

White pine. Pine with five leaves and long cones: the maritime pine appears to be a variety of this.

Red pine. Pine of Canada, with two leaves, and the cones of a moderate size and of flatted oval figure.

The soil, age and size, have less influence upon the quantity of turpentine, than the aspect or exposure, and thickness of the bark. Pines exposed to the south and the rays of the sun, yield great quantities: those which are covered with a very hard bark furnish less. Pines growing too near each other contain but little resinous juice; it is requisite that there

be between them an interval of twelve feet. However, the nature of the soil, and its position with respect to the sun, ought to regulate a variation of this distance. Care is taken to lop off the young branches which grow upon the stem; and by this mean the tree attains a greater height, and the trunk is more exposed to the sun.

High pines in rich soils, and in rainy seasons, do not yield a sap of so good quality.

Young pines furnish turpentine as well as the old; but the extraction of it enfeebles them.

The resinous matter flows more especially during summer.

The pine yields it during from twenty to twenty-five years; and the extraction is begun when the tree has attained twenty years growth.

The resinous juice flows almost solely from the ligneous substance, and from between the wood and the bark; the exterior rings of wood yield more than the interior: and only a few drops of beautiful quality transude through the bark. The roots also furnish much juice. The knots contain more resinous matter than

the other parts of the tree; the roots contain more than the branches, &c.; and the ligneous part, near to the incisures or the scars, supply it still more richly.

When the pines are of about twenty years growth, they have acquired a circumference of about three or four feet, and are sufficiently strong to admit of the extraction of the resinous sap, which circulates through the different parts of the tree.

The sap begins to flow in the spring; and in this season the trees are cut, in order to extract the product of it.

The fluid exudes till autumn. In general it begins to flow in May, and ceases in September.

In order to facilitate the discharge, and confine it to one point, a space of three inches broad, and six or eight long, is chosen at the bottom of the tree, near to the ground, in the part which is most exposed to the south, and in the place which appears most abundant in sap, and disposed to let it flow; the bark is taken off by an axe, and a splinter of wood is cut out by a rounded adze: the turpentine soon begins to flow, and is seen to transude

through the ligneous fibre in transparent drops; it flows over the bark of the lower part, and falls into a hole made at the foot of the tree to receive it, or into a small vessel placed there for this purpose.

When the discharge has subsided, the wound is extended towards the upper part, and another splinter is cut from the ligneous fibre; it is necessary to repeat this at the expiration of about fourteen days.

The incisure is therefore progressively enlarged; and, at the end of the year it has attained the length of a foot. The operation is discontinued when the return of the cold congeals the sap and stops the discharge.

In the following spring the wound is again renewed; and at the end of five or six years it will have acquired the length of five or six feet.

When it has acquired this extent, a fresh incision is made at the foot of the tree, almost close to the former one, and it is enlarged progressively and in a parallel with the first.

While this wound furnishes the turpentine, the first cicatrises, in such a manner that we may proceed through the circumference of the

tree, and operate upon the scars of former incisions.

In refreshing the wound, it is necessary to use the precaution of taking only very thin cuttings of the wood.

It is necessary that the workman use very sharp implements. These precautions affect both the vigour of the tree and the quantity of sap which may be extracted.

One person is adequate to the management of two thousand five hundred, or of two thousand eight hundred trees; he pours into barrels the turpentine collected in the vessels placed at the foot of the tree to receive it, and it is in this state sent into the market.

That of the ci-devant Guienne is known by the name *galipot*; and that of Provence by the name of *perinne vierge*. In some parts of Provence, they have the custom of excavating a small hollow at the bottom of that which receives the turpentine, and separating the two cavities by branches of rosemary, which are placed at the orifice of the second.

The more fluid part of the turpentine filters through, and passes into the smaller cavity: this turpentine is known by the name of *bijon*.

A vigorous tree will yield from twelve to fifteen pounds of turpentine every year.

From the autumn to the spring, the small quantity of turpentine which is discharged from the tree congeals on the surface, whence it is detached by an iron rasp fixed at the end of a stock. This turpentine is known at Bordeaux by the name of *barras*.

In order to manufacture the yellow dry resin, known in commerce by the name of dry *brai*, and in Provence by that of *rase*, they place over a fire a copper boiler, the borders of which, to the extent of some inches, are turned back: in some part of the border a spout is made, from six to eight inches long, and under the spout a trough is placed, which is made in a block of pine, and which is filled with water.

The turpentine, both liquid and hard, which has been extracted from the pine, is put into the boiler; this matter fuses at a moderate heat: when in a state of fusion, water is added to it, the turpentine then swells, and part of it flows into the trough; this the workman continually returns into the boiler; he agitates and thoroughly mixes the whole, and continues

thus to proceed till the whole of the water is dissipated. The melted mass becomes more tranquil towards the end of the operation, and assumes a yellow colour; and in this state it is poured into another trough, where it is filtered through straw, to pass into moulds which have been carefully formed in sand.

These moulds are round holes, the sides of which are well beaten and very smooth; and the cakes of resin, which take their form, weigh about 200lbs.

If, instead of boiling the turpentine in an open vessel, it be boiled in alembic with water, there passes over a kind of turpentine named pitch water, and which is very inferior to the true oil of turpentine.

If we put the galipot into troughs formed by a collection of planks, and expose them to the sun, the part which exudes through the cracks is known by the name of *turpentine of the sun*.

The galipot melted in a cauldron is called *turpentine of the cauldron*.

The most fluid kind of galipot has been also classed among the turpentines; but it is the very worst of all: it is inferior to that of

the larch tree, and particularly to that of firs.

The living tree does not furnish all its resin from the incisions made in its trunk; but, as soon as it is dead, it is submitted to an operation, by which the resin is extracted to the last atom: and this resin, extracted from the dead tree, is called tar.

In order to extract the tar, it is only necessary to apply to the parts of the wood which contain it a heat sufficient to soften and make it flow out, without inflaming or volatilizing it.

This object is attained by arranging in a heap pine wood, cut into small pieces; the sides of this heap are covered with earth, turf, or bricks; the whole mass is heated by the fire, which is applied to the upper part, and all the resin is collected, which flows towards the bottom into gutters, which carry it out from the heap.

The furnaces in which this smothered combustion takes place are of different forms and dimensions. But in all the processes known, there are common principles and practices, which we shall detail.

In order to extract the tar, the heart of the tree is chosen, together with the knots and resinous veins.

The red parts are preferred.

The bark and leaves are rejected, as furnishing an inferior sort of tar.

Straw is used, through which dry pitch has been passed, and chips which have been taken off the tree in order to renew the incisions.

In the preparation of tar, they also use trees which have been exhausted of resin, those which have been torn or rooted up by the wind, and the chips produced by the various operations performed with wood.

The tar is so much the better the more resinous the trees are which furnish it, and the more attention that is paid to reject the bark and young branches, and the more methods that are devised to oppose the combustion and volatilization of the resin.

In order to obtain good tar, it is also very essential not to employ wood too green or too dry; a degree between the two extremes should be preferred.

We may cut the wood at all seasons; but it is particularly in autumn that it is prepared for

these purposes, and it is during winter that the tar is distilled.

The wood must also be divided into thin and equal parts, in order to extract in the same period all the resin which may be contained in it.

The management of the fire also requires very great attention. 1. A too active fire burns or dissipates the resin. 2. A too strong heat volatilizes it, and produces a kind of tar too dry. 3. A smothered and feeble heat extracts a small part of the resin only, and leaves in this produce the aqueous principle which was in the vegetable.

A furnace charged with very red and very resinous wood furnishes a fourth in weight of tar; but in general no more than 10 or 12 per cent. is obtained.

All the various furnaces used for the extraction of tar, in my opinion, have their advantages and inconveniences.

In the mountains of Provence, the furnaces are shaped, like large water pitchers, one part of them being sunk in the earth; they are 18 inches diameter below, 5 feet in the belly, and 2 feet at top.

The wood is cut into pieces, 18 inches long by one and a half broad; they are arranged in beds, so as to form grates, the empty spaces of which are filled by chips and shavings,, or other pieces arranged perpendicularly.

In the neighbourhood of Bourdeaux a circular ditch is made, from 36 to 48 feet in circumference; a star formed building of brick, for supporting the pile of wood, is erected in the centre, containing a small channel, through which the tar flows, and is received in a place dug below it, which is called the cellar. This cellar contains water, in order that the tar may purify itself; and it is then put into casks and conveyed to the store-houses. The pile consists of wood cut into small pieces, and is 8 or 10 feet high. The sides of it are covered with turf and earthen sods, and the upper part of the cone is then lighted. The layer of wood at the top is drier than the rest, and the heat soon communicates downwards. When the fire slackens, they facilitate the draught by taking away some of the turf or sods from the sides, and thereby revive the fire.

When the operation is finished, all the aper-

tures are closed, and a few days afterwards the charcoal is extracted which is formed.

The furnaces used in Louisiana differ very little from that we have now described; with this difference only, that the ground is not covered with bricks, and the sloping of the ground alone, which is strongly beat, so as to render it very hard, directs the flowing of the tar, which, by means of very long gutters, runs into reservoirs made in the earth.

The process adopted in the Valais, in order to extract tar, is practised by all the peasants indiscriminately; and as it presents us with all the methods proper for avoiding the loss of the tar, and obtaining it of a good quality, we shall describe it very minutely, adding all the inconsiderable changes which observation and experience have suggested.

A furnace is constructed, shaped like an egg, standing on its smaller end. The dimensions may be varied, according to the quantity of wood to be burned: it should be, in general, two feet higher than it is broad. The largest may be nine feet high, five feet diameter, and two and a half at the upper aperture.

In order to construct the furnace, we must begin by tracing out the dimensions of the base, and stone walls are raised two-thirds of the total height. The interior is lined with hewn stone well joined, or with bricks well cemented together. The bottom is hollow, like the bottom of an egg-shell. Five inches from the bottom, a hole must be made, 18 lines in diameter, which goes completely through the furnace, making it slope about six or eight inches. To this orifice is adapted a thick iron pipe, or a musket barrel of large calibre, for conducting the tar into casks intended to receive it.

About 20 or 25 inches from the bottom of the furnace, parallel bars of iron are placed, capable of supporting the wood, and of allowing the tar disengaged by the heat to flow down to the bottom.

The construction of the furnace is finished by shards of earth; and at the upper part an aperture is kept of two feet and a half in diameter, through which to charge the furnace conveniently.

It is coated carefully within and without, and we should have the precaution to close

up any cracks or chinks the instant they are observed.

It is almost needless to observe, that we may substitute whatever substances are readiest at hand, in place of those we have now described.

It is also of advantage to make some holes in the sides of the furnace, that we may occasionally use them for facilitating the draught and graduating the heat at pleasure.

When a furnace of this description has been constructed, a man goes into it and arranges the cut wood into beds of two inches broad by eighteen long, laying them along the grating; he then fills the whole capacity, taking care that there should be no empty spaces, and he places dry chips of wood at the top.

The upper orifice is closed with flat stones, or plates of cast iron or copper, so as to leave a chimney only about four inches in diameter. The upper chips are then lighted; and when the fire is well established, this aperture is closed with a flat stone covered with earth. When the distillation begins the tar flows down: it fills the bottom as high as the lower

orifice before described, and it then flows out through the pipe into the outer cask.

If the distillation stops, the aperture must be re-opened, and currents of air are also made to enter through the sides.

If the smoke issues through the sides, the fissure must be stopped up with soaked clay or turfs.

The furnace is not opened until it is cooled; the charcoal produced by the operation is then taken away; the gross and impure matters collected in the bottom are also extracted, and the furnace is filled again as before.

It will be seen that the construction of such a furnace, which is neither troublesome, costly or difficult, occasions no loss, and the tar must be finer, because the furnace being constructed in a solid manner, foreign substances cannot be mixed with it; and besides this, preserves all the principles, which other furnaces allow to be lost.

The expence of such an establishment is fully overbalanced by the advantages it presents: besides, it is built in the midst of the woods, and is consequently surrounded by materials for keeping it at work. Such a

furnace is also stable and permanent, while the other kinds must be demolished and rebuilt at each successive operation.

If all the above precautions are attended to, the tar produced in France will soon rival that of the North of Europe.

Another resinous preparation is also known in commerce by the name of *fat pitch*. It is prepared by filling the furnace with alternate strata of green wood, dry chips and resin, and dry pitch, and finishing the upper layer with dry chips. The lower aperture is closed, by which the resinous juice might flow out, and the furnace is lighted.

Great care must be taken to smother the fire, and to produce a dead heat, which must be continued for seven or eight days. The resin melts, is mixed with the sap, and flows to the bottom of the furnace. When the operation is finished, the lower channel is opened, and the fat pitch flows out by it.

By mixing the dry pitch with very resinous wood, and not opening the channel of discharge until the resinous substance is prepared, fat pitch is obtained.

In order to make *lamp black*, the small pieces of the refuse of all kinds of resins are placed in iron kettles; these are placed in the middle of a small apartment, well closed, and every chink stuffed with cloth and paper: these pieces of resin are then lighted: a thick smoke is liberated, which fixes upon the walls and the roof; this is called lamp black.

This operation should be performed in detached buildings only. The lamp black produced by it is used in painting, dyeing, printing, varnishing, &c.

CHAPTER IV.

Of some compound Substances extracted from Animals and Vegetables.

SECTION I.

Of the Juices of Vegetables.

NO one can be seriously occupied with the chemical study of vegetables, without being convinced of the difficulty of classifying, in a methodical manner, their different principles.

Without doubt, their carbon, feculum, resin, oil, and mucus, have striking characters, which distinguish them; but the difference in proportion, mixtures, heat, light, and air, produce such modifications in all these products, that the substances undergo metamorphoses as it were every instant: the feculum assumes the character of mucus in warm water, the oil thickens by means of oxygen, and there are no genera in the vegetable products to which we

cannot add appendices: thus indigo may be attached to the feculent vegetables, caoutchouc to the resins, camphor to the volatile oils, &c.

It seems now proved that carbon, hydrogen, and oxygen, form the three essential principles of vegetables.

The proportions among these principles determine all their differences.

The characters peculiar to each vegetable product, announce, in a great measure, the predominance of this or that principle.

The most volatile products abound in hydrogen, and are in general very little soluble in water.

The fixed products being not rich in hydrogen, such as mucus, wood, and extract, abound in carbon.

Oxygen predominates in the acid products.

We may extract, by various processes, the one or the other of these principles, and cause one of the three to predominate, so as to give the character we desire to each of these products, or at least to alter the nature of the primitive product.

In vegetables as well as in animals, there exist juices that are common to all of them, as well as fecula, or organic juices.

The common juice is called *sap*. The peculiar juices are the result of the elaboration of the sap in the various organs, where it assumes peculiar characters, which form juices from it of very different natures.

Although the vegetable does not present in the humours, that uninterrupted movement which, in the animal, carries the blood into all parts, and conducts it towards the center, where the focus of action is; we cannot refuse to allow a movement to the sap, which carries it through all the parts of the vegetable.

The movement of the sap is more or less rapid, according to the degree of atmospheric temperature, according to the age of the plant, its exposure, and the season of the year.

It is this oscillation of the sap in the body of the vegetable, that enables us to make it flow from a tree by means of incisions.

The juices vary in the same vegetables, according to their age, the season of the year, their exposure, the nature of the soil, climate, &c.

As it is important to know these modifications, we shall successively point them out.

Young plants present us with pulp only, in which the carbonaceous principle predominates.

This mucous principle is elaborated by the action of heat and light; and there results from it all the compounds which form the different parts of the vegetable.

Water is the substance essentially nutritive to the plant; and it is in its decomposition, and in that of the carbonic acid, that it finds all the principles necessary for its growth.

As the plant developes itself, the carbon is separated in order to form the base of the ligneous product, while the hydrogen joins a little oxygen and carbon, in order to produce the oils and the resins.

The vegetables, in spring, may be considered as in their state of infancy, with respect to the nature of their humours. The young shoots are all mucilaginous; and it is afterwards, by the action of heat, that those juices form the different products of vegetation.

When the season is rainy, these juices are not completely elaborated, and the plant only produces a ligneous texture. Heat is wanted for forming the oils and resins.

The plants gathered in spring, and in the

vigour of their growth, burn with difficulty; their volume diminishes much by desiccation; they rot very soon. Their taste is insipid, their smell almost nothing.

These same vegetables present very different characters, when they have arrived at that state of maturity which is the term of their annual increase.

The cause of the difference in the products, arises wholly from the changes occasioned in the vegetable by the progress of the elaboration of the juices.

In spring, all is mucus in the plant; at the end of summer, the mucus has disappeared, and we find oils, sugar, fibres, principles, almost all of them eminently combustible, insusceptible of putridity, and not very evaporable.

Dr. Plot observed in 1691, that all trees cut down when green, are subject to the attacks of insects, that they shrink in drying, diminish considerably in volume, and do not powerfully resist the destructive action of air and water.

Pliny and Evelyn have bequeathed us similar observations. Julius Cæsar had already observed, that vessels built of green wood were unwieldy, and did not last so long.

Vitruvius advises us not to cut trees, except at the end of winter: *quia acris hyberni vis comprimit et consolidat arbores.*

In Staffordshire, the trees are stripped of their bark in spring, and they are never felled until the autumn afterwards. Buffon has proved that the contact of the air hardened wood which was stripped of its bark; and he suggests this as an advantageous method of procuring good wood.

Every one knows, that the trees which are cut in a forest exposed to the north, are less combustible than those exposed to the south: the former are charred and blackened in the fire; the latter produce flame easily, and yield good charcoal.

It results from the constant observations of naturalists, that plants reared with a south aspect, lose their fragrance and taste when removed to a northern exposure.

Pliny observes, that the woods which grow on the south of the Appennines, are harder and more durable than those to the north of the same mountains.

The exposure of gardens and orchards, under the same climate and on the same soil,

produces infinite modifications in the nature of the fruits and leguminous plants which are cultivated in them.

Vegetable products have neither taste nor smell, if the plants which furnish them are shaded by trees of thick foliage.

Plants whose climate is changed, change their nature with respect to their products. It has been remarked by English navigators, that some vegetables, insipid and inodorous in Greenland, acquired taste and smell in the London gardens.

According to Regnier, the blue mellilot, which has a penetrating smell in the southern climates, has none at all in Holland.

In general, vegetation is stronger in the countries of the north, but the products are less varied.

The mucous body, which is developed in all climates, but which requires heat in order to produce oils, resins, &c. not being properly elaborated in cold climates, is entirely applied to the growth, and forms the ligneous body.

The influence of the soil is also very remarkable upon the vegetable. In general, plants raised in a parched soil are rich in volatile oils,

while the vegetables of the same nature, raised in a humid soil, have neither taste nor smell.

All these causes, which so powerfully influence the vegetable, vary its properties and virtues in an astonishing manner.

The same plant has not the same virtues in spring and autumn; when it is young, or when it is in full growth; when it is raised in a south exposure, or in a northern one; in a dry soil, or in a fat one.

The juice of a plant in spring, is generally more aqueous and more putrid than in autumn.

A plant arrived at maturity, contains more oil, more fibres, and less juice.

The artist and physician should pay attention to these differences, and regulate their conduct accordingly.

In spring, and at a tender age, the plants are laxative, resolutive, and of easy digestion.

In autumn they are harder, less succulent, more oily, more ligneous, and more combustible.

It follows from this, that the plants of the north are not the same, with respect to virtues, as those of the south; that, consequently, the effects belonging to juices extracted in the

north or south, cannot correspond. There are plants which are poisons in the south, and which are used as food in the north: the *aconitum napellus* is a proof this. What is observed in plants, applies to animals also; some of which are only venomous in the south, or during the heat of summer.

A physician should therefore confine his observations to his own country, when he writes upon the virtues of plants. The results of his observations should be modified, according to the soil, the climate, exposure, age, &c.

It is the same with all the vegetable juices as it is with the juice of the grape, which is sweet in the south, and insipid or acid in the north.

These observations essentially interest all mechanics who use wood in their occupations, as well as dyers, who extract colouring matter from them; and, generally, all who operate upon vegetables. Fortunately, practical observations have enabled us to speak with accuracy on the subject.

In order to extract the juices from the various vegetables which contain them, processes are resorted to, which vary according to the

quality of the juices and the nature of the vegetables.

Sometimes they ooze out of themselves; and in this case, they are collected in the bodies of the vegetables where they are fixed.

Often it is only necessary to make an incision upon the vegetable, in order to draw off the juice which circulates in it. It is still more frequently necessary, however, to apply a strong pressure to the texture of the plant itself.

And when the juices resist the pressure, water is resorted to, in order to dissolve them, and bring them out.

I. *Extraction of the Juices by Means of Water.*

If we wish to extract the juice from a plant, the texture of which is dry and thick, or that from a hard and solid wood, water is used as a vehicle proper for penetrating the texture of the vegetable, and dissolving its juices.

Water is applied at different degrees of temperature, and it is made to act for a longer or

shorter time, according to the nature of the juices, their degree of consistency, and the hardness of the texture.

If a flower is acted upon, the principle of which, perhaps very transitory and evaporisable, would volatilize at the heat of boiling water, we content ourselves with putting it in warm water, and allowing it to remain some time, that the water may be impregnated with its principles.

All the odoriferous plants are treated in this manner: the continuance of the digestion and the heat of the water, are proportioned to the volatility and solubility of the principles we wish to extract and preserve.

Water applied to vegetables in this manner, constitutes the operation called *infusion.*

But if the vegetable texture is very hard, and if we are not afraid of losing any aromatic and volatile principle, the water is then boiled upon the vegetable, and this operation is known by the name of *decoction.*

Frequently ebullition is employed for extracting the fugacious principle of plants, called *aroma*, and which is only a portion of oil kept in a volatilized state; but, in this case,

the produce is collected in an apparatus, closed in order to avoid all loss: the operation is then called *distillation*.

When we extract, by means of water, the principles of any plant, they are thickened by evaporation, in order to form *extracts*.

The extract presents, in a small volume, all the soluble principles of a vegetable: it furnishes us with the means of preserving the nutritive and medicinal properties of plants; it admits of our using the juices of vegetables in all climates, and at all seasons.

Extracts should be made with great care: the sweetest juices, such as that of the grape, contain acids that corrode copper vessels, and bring into the extract a deleterious principle. When we inspissate the juice of grapes, in order to make a comfit of it, care should be taken to keep two or three iron keys in the copper vessel during the ebullition, and the keys, when taken out, are covered with copper: this proves that a portion of the metal has been dissolved, and afterwards precipitated by the iron.

Chemists and apothecaries cannot be too careful in the choice of their evaporatory vessels: those of silver, glass, or stone, should be preferred to copper, lead, or iron ones.

It is usual to depurate or clarify the juices of vegetables; and the processes are different, according to the nature of the juices.

Sometimes the white of an egg is beat up with the juice, and it is heated in order to coagulate this animal matter, which seizes all the impurities, and collects them at the surface. Such juices can alone be treated in this manner as are fixed, and capable of undergoing ebullition without any loss.

Simple repose, immersion of the vessel containing the juice in warm water, and successively in cold water, is sufficient to clarify certain aromatic juices.

There are also some juices which may be purified by plunging into boiling water the bottle containing them. The juice of cresses is one of this description: we see flakes detached from it, which rise to the surface, and they are precipitated upon cooling: the juice then becomes more limpid; and, by decanting or filtering it, we may obtain it very clear.

This property possessed by some juices, of fixing themselves by heat, proceeds from a portion of albumen which exists in them, according to the observation of M. Fourcroy.

When we wish to apply vegetables to our domestic purposes, the infusion or decoction is used according to their nature.

An infusion is made when the aromatic principle is to be preserved, and the extractive matter which the plant contains, is to be rejected. Thus tea and coffee are made by infusion, while almost all the plants used in cookery are treated by decoction.

It is not a long time since a method of cooking vegetables by steam was made known in France: this is effected in an apparatus called an *American kettle*. It consists of a cucurbit, in which a water bath is enclosed, pierced with small holes over all its surface, and isolated in the cucurbit, so as to touch the upper edge only. Its aperture may be closed by a lid, which is adapted to it very exactly.

The vegetable is placed in this water-bath, and the water in the lower part is made to boil.

This process has certainly the advantage of preserving to the vegetable, its juice and all its taste, of not altering its colour, and it even admits of our using salt-water in cooking our victuals. But it requires more time, and does not take away the bitter taste which some vegetables have.

II. *Extraction of the Juices by Incision.*

Although the circulation of the juices of the plant is not so regular as it is in the animal being, yet we cannot refuse admitting, that in the sap is a movement, which carries it to every part. But this movement, in place of being an effect of the vital powers, seems almost entirely regulated by the action of light and heat.*

Nevertheless, vitality is too strongly marked in the plant, to admit of our granting to external agents all the effect and all the work of the circulation of the sap. We know, from the experiments of Buffon and Hunter, that cold and heat are not applied regularly and passively to the living plant; and although the external agents exercise upon it a very marked action, we are forced to acknowledge that it is modified by vitality.

The plants are placed by nature in the last

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* We may see in the writings of Messrs. Mirbel and Decandole, the description of the vegetable, and the theory of its functions developed with great sagacity.

degree of the scale of living bodies; and we may distinguish in all their functions, the combined action of vital powers and of external agents.

Thus, when the return of spring produces heat, and dissolves in the vegetable the fluids coagulated by winter, the irritability is also awakened by heat; the play of the organs is excited, and the order of the functions which constitute life recommences.

The juices then become fluid, flow throughout the cellular texture; and if their movement is interrupted by any obstacle, if deep incisions break the envelopes which contain them, they are seen to escape by the orifices that have been made.

It is this flowing out of the juices, sometimes natural, but more frequently produced by art, which furnishes the means of extracting several vegetable juices; such as the gums and resins.

These two products, which may be softened by a gentle heat, are those which may be extracted the most easily without altering the vegetable. The gum even oozes out naturally from the tree, and is fixed upon its surface:

we see every day, tears of gum upon the cherry, the plumb, and the apricot trees. It may be said, that at the moment of the oozing out of the sap, there was a plethora of humours, and that the tree freed itself from the superfluous juices by pushing them out of it.

The resinous juices are not constantly furnished by the trunk of the tree.

The leaves and the fruit sometimes furnish it. Tournefort informs us, that the resinous leaves of a *cistus* of the Levant furnish the gum called *ladanum:* the roots of one of the *convolvuli* give scammony; aloes are extracted from the leaves of the *aloes vulgaris;* and the fruits of the *toluifera* contain the balsam of Peru.

These resinous juices are not all exactly of the same nature: they have been divided into three grand classes, as the resinous principle is pure, or mixed with the benzoic acid, or combined with an extractive principle.

The first are called *resins,* the second are *balsams,* and the third are *gum-resins.*

The resins are entirely soluble in alcohol, and not in water.

The balsams are dissolved in alcohol. We

may extract an acid from them by sublimation, or by means of water.

The gum-resins are soluble, partly in water and partly in alcohol: they render the water milky in which they are boiled.

The resins most employed in the arts, are the turpentine, and the resinous principles of the pine-tree.

All the larch and fir-trees furnish a resin known by the general name of *turpentine.* Commerce distinguishes several qualities, according to their degree of goodness.

One of them is known by the name of *turpentine of Chio,* and it is furnished by the pistachio-nut-tree. It is fluid, and of a yellowish white, inclining to blue.

This plant grows in Cyprus, Chio, and in the south of France. It is by incisions made upon the trunk and the larger branches, that this juice is extracted.

The larch tree furnishes *Venice turpentine:* it is made to flow from the trunk of the tree, by making holes with an augre, in which small pipes are fixed, which conduct the juice into buckets.

This turpentine has a yellowish and limpid

colour, a strong aromatic smell, and a bitter taste.

The *resin of Strasburg*, and the *balsam of Canada*, are turpentines extracted from the fir-tree.

The fir-tree with leaves like the yew, very common in the mountains of Switzerland, furnishes the former. The peasants collect it by perforating the *sacs* which contain it under the bark, with the point of a horn, which is filled with this juice.

The distillation of the turpentine liberates an oil, more or less volatile, according to the degree of heat employed. When the operation is done in the *balneum mariæ*, a white, limpid, and odoriferous oil is obtained, which is called *essence of turpentine:* when the distillation is effected on the open fire, the oil extracted is heavier, and slightly coloured; and it is then called *essential oil of turpentine.*

The residue from the distillation forms the *boiled turpentine of commerce.*

The *turpentine of Chio*, and that of *Venice*, furnish the best products.

The volatile oil of turpentine is of great use

in the arts. It is used in particular in dissolving the resins, and forming varnishes.

It has the inconvenience of drying more slowly than alcohol; but it has the advantage of not cracking like alcohol, and of preserving to the varnish a pliability, which admits of its being polished.

All the qualities requisite in a varnish may be united, by employing alcohol and essence of turpentine in proper proportions.

Turpentine also enters into the composition of the varnishes, which are rendered pliable by it; while the other resins give it what is called body, or colour.

Turpentine incorporated with gum lac by a brisk fire, and coloured with vermillion, forms *sealing-wax.*

It may be rendered more or less capable of being melted, by varying the proportions of the turpentine.

The quality of it is lessened, by mixing colophon with the turpentine, and colouring the mixture by red-lead.

It may be perfumed and coloured at pleasure, by combining with the bases of its composition any of the known aromas, and the colouring principle of the varnishes.

III. *Extraction of the Juices by Expression.*

We have already observed, that it is not sufficient that the juices of vegetables should have a fluidity proper for allowing them to flow out; there must also exist a free communication between the cellules, in order that they may flow in abundance by the incisions made in a part of the tree.

When these communications do not exist, we cannot extract the juice of the plant except by a strong compression, which breaks the cellules containing them, and squeezes them out.

The process generally adopted in all cases, consists in bruising the plant in a mortar, in order to form a paste of it, which is inclosed in linen, and submitted to the action of a press, in order to extract all the juice. Nothing remains but a pulp after the pressure of the plant.

The juice which flows out always carries with it a little ligneous pulp, which is precipitated on allowing it to repose.

When the substance from which we wish to

extract the juice, is very dry, it is necessary to wet it before putting it under the press.

We may, in several cases, soften the juices by heat, and prepare them, by this means, for flowing faster under the press. This is done when oil of almonds is extracted, the paste of which is placed between too hot iron plates; and when we press olives, they must be sprinkled with a little hot water, in order to make a portion of the oil flow, which is very adhesive to the parenchyma, and to the extractive principle.

SECTION II.

Of Sugar.

Sugar abounds in vegetables, of which it forms a principle *sui generis*.

For the uses of society, they prepare only the juices of those vegetables which contain the greatest quantity.

But all sweet and saccharine juices do not furnish sugar of the same nature: Messrs. Dey-

eux and Proust distinguish them into two kinds: one constantly fluid, capable of fermenting without any addition; the other susceptible of yielding crystals, and incapable of fermentation, but by mixing it with the first, or with some other kind of leaven. This last is the most esteemed: the sugar-cane and the grape are the vegetables which contain the most. This is, nevertheless, intimately united with the sweet and saccharine liquor we have been speaking of.

In almost all the vegetables which contain a sweet principle, the liquid sugar is more copious than that susceptible of being crystallized. There are even some that cannot be brought to crystallize, and which remain always in a humid and syrupy state.

We still want experiments to ascertain certainly the nature of this liquid sugar; yet, as this substance can be fermented by itself, and as it furnishes a very spiritous liquor, which is called *rum*, it doubtless contains both sugar and that vegeto animal matter which serves as leaven; and it is to be presumed that this vegeto-animal matter, which thickens and coa-

gulates by the heat, retains a little of the sugared matter, and prevents the crystallization.

It is further to be observed, that the proportion of this liquid sugar is much more considerable, when the juice of vegetables of the same kind has been elaborated in a hotter climate. Thus the same grape, cultivated in the south of France, or in the north, yields crystallizable sugar in the south, and does not in the north, although the juice be very saccharine. The fine *chasselas* of Fontainbleau have a very sweet and very sugary taste, though they furnish much less sugar than in the climates of the Levant, from whence Francis the First brought them.

It would appear, then, that the vegeto-animal part is abundantly produced in the vegetable, but that the perfect maturity of the fruit diminishes the proportion of it, and augments that of the crystallizable sugar. Though the liquid sugar can ferment without the aid of any foreign substance, it does not produce alcohol but by reason of the sugar therein contained. We may even be often deceived on this subject, by the sweetish and strongly saccharine taste of the juice of a grape, which might be thought

very proper to produce a great deal of alcohol by fermentation, and which gives but very little, because it contains very little sugar. It is also well known, that the sweetest grapes do not furnish the most generous wines. The sweet flavor of the chasselas, is not the sugary savour of the southern grapes, and the produce in wine is very different.

Manna, which is furnished abundantly in warm climates, from the ash, the larch, and the *alhagi*, and which is extracted from the pine-tree, the fir, the olive, the mapple, the fig, the willow, &c. contains also a sugary matter, but this sugar preserves a moisture and an insipid taste, which are almost inseparable.

The mapple, which grows abundantly in North America, furnishes sugar to commerce; but this sugar is less soluble than that from the sugar-cane, and it sweetens less.

Margraaf had shewn the existence of sugar in the beet-root. Mr. Achard, of Berlin, has lately proposed the cultivation of this plant, in order to extract its sugar. But the favourable opinion which was at first conceived, has not been supported; and MM. Deyeux and Parmentier, who have repeated his experiments

with the most rigid care, and without any prejudice, have arrived at results which do not permit them to regard this object as economical.

It appears that it is not so with the proposition of Mr. Proust, which is founded on positive facts, and on calculations which announce that there would be much to be gained in southern climates, by extracting the sugar of the grape. His experiments were made in Spain, where the raw sugar from the grape furnished him, by the hundred weight; *viz.*

	lbs.	oz.
Crystallizable sugar . . .	75	0
Liquid sugar	24	7
Gum	11	5
Malate of lime	11	4

He prepares this raw sugar in the following manner:

After having scummed the new wine, they throw into it, while it is yet fermenting, lye ashes, at different times, just until the effervescence ceases.

They continue to boil it until it be reduced one half; then it is left to cool.

During this repose, the tartar and the citrate, and even the sulphate of lime, which are proper to the juice of the grape, precipitate.

The new wine then marks 25 or 26 degrees by the areometer of Baumé.

It is beat with the whites of eggs, or with bullocks blood; it is heated, scummed, and filtered, and they finish by boiling it to the consistence of a syrup. This raw sugar has a very sweet and pleasant taste; it congeals in eight, twelve, or fifteen days.

The syrups the least boiled are the first to yield their sugar. The juice, clarified and boiled to the point that it only leaves forty parts (in the hundred) of extract, has crystallized sooner than that reduced to 35,00. The juice reduced to 32,00 has not crystallized, by the experiments of M. Proust.

The refining is then made by the same process as that of the raw sugar from the sugar-cane.

The first difference in the product, is that the sugar from the grape never offers but a powdery grain, and that the mass which it yields presents but very little consistence.

Grape sugar refined by three crystallizations,

has a savoury relish; it is without smell, or after-taste. But its sweetness is inferior to that of sugar from the cane. It does not sweeten as much, weight for weight, and it is less soluble.

Even to this day, almost the whole of the sugar known in commerce, is derived from the sugar-cane, which is cultivated in all very warm climates. That which grows in Europe produces but little sugar; and though at sundry times they have proposed to naturalize it in the south of France, in Spain, and in Italy, we must own that it would be giving an unprofitable direction to industry.

This plant is reproduced by slips, with wonderful fecundity.

It appears that it was carried to St. Domingo in 1506, by Peter d'Etienca, and that it is indigenous in India and beyond the Ganges.

Michael Balerto passes for being the first who pressed the juice from it at St. Domingo; and it is pretended that Gonzales de Veloza was the first that extracted sugar from it.

Sugar-canes arrived at maturity, are cut, bound in bundles, and carried to the mill,

where they are pressed betwixt three large iron cylinders, placed in a row.

They pass the canes twice between the cylinders; the juice which is pressed out runs into a tray, from whence it is conducted by pipes into the reservoirs. In this state it is called *vezou*.

Since 1725, they have replaced the iron boilers by copper ones, and they place five on the same furnace. This collection is called equipage or furniture.

In the first, which is called the great boiler, they mix the vezou with chalk. From the first they pass it into the second, which is called the cleaner: there it deposits sediment. From the second they carry it to the third, or the purifier. They thicken it to the consistence of syrup in the fourth, which is called the syrup: and they terminate the evaporation in the fifth, or the *battery*, because the swelling which it produced, is stopped by beating the matter with the skimmer.

As the scum rises in each boiler, they take it off with the skimmer.

We have observed, that the boilers were constructed on the same line. The furnace is

placed under the battery, so that the heat is most intense at this place; and that it decreases gradually, as it is farther removed from the furnace.

When they wish only to obtain raw sugar, they raise the fire so that the ebullition causes the thermometer of Reaumur to rise to 94 or 97 degrees.

When they desire to make clayed sugar, they stop the fire at 90 degrees.

The whole being brought together, is emptied into a cooler. There they mix well the products, and carry them into a large tub, in which the crystallization operates, if they wish to make raw sugar: they pour it into earthen cones, if it is clayed sugar which they propose to make.

When the raw sugar is crystallized, they take it to the purging house, and there they place it to drain in casks, pierced with holes in their bottoms, through which the molasses runs.

The raw sugar, thus drained and dried, is put into barrels, and carried to Europe; where it is disposed of under the name of *raw sugar, brown Muscovado,* &c.

The sugar destined to be clayed in the manufactory, is disposed in earthen cones turned upside down, of which the hole at the point is stopped: there it is left to cool for fifteen days; after which they open the pots, and the molasses runs into tubs, upon which the cones are inverted.

Twenty-four hours afterwards, they unite carefully the base of the sugar-loaf, and they cover it with a layer of diluted clay. The water filters by degrees through the mass of sugar; it dilutes, and draws along with it the molasses, which dirties the crystals of the sugar.

When the first layer of clay is become dry, they substitute another, and continue until the sugar has acquired the degree of whiteness that is desired. This is then what they call *white cassonade*, or *clayed sugar*.

As they do not submit the sugar which they intend to be clayed, to so strong an evaporation as the raw sugar, the thick syrup that drains from it is found to be more rich; and they distinguish the syrup of raw sugar, or Muscovado, by the name of *covered syrup*.

In fermenting the molasses, they make a

liquor called ratafia; and in order to do this, they dilute it with water, so as to mark 12° of the barometer of Baumé, and they proceed to the fermentation, the vinous distilled product of which makes rum and ratafia.

The raw and the clayed sugar brought to Europe, are there submitted to new operations, by which they are freed from all the molasses which they might contain, and they form from them that which is called white or refined sugar.

In order to form an exact idea of the refining the juice of the sugar-cane, it is necessary to bear in mind the following principle, viz. that this juice contains, besides the crystallizable sugar, a substance sweetish and incrystallizable, and also an acid which reddens blue paper; it is necessary to separate these two last principles from the sugar, properly speaking. They attain this by saturating the acid with lime-water, and alkaline lyes, &c. and in coagulating by heat part of that sweetish incrystallizable matter; and by bringing it to the surface of the tub, or vat, by the white of eggs, or by bullock's blood; in drawing together the sugary juice by evaporation to the point of bring-

ing to crystallization the true sugar; and, lastly, in diluting or dissolving by water the viscous, syrupous, and incrystallizable matter.

We have already seen, by the detail of the first operations which they execute upon the juice of the cane, that all of them tend towards the end we have announced. We shall see that the operations of refining are conducted with the same views. We will take the refining of raw sugar for an example.

At first they dissolve it in lime-water; they clarify it with bullock's blood; and they submit it to a rapid and forced evaporation, taking care to take off the scum as fast as it forms.

This dissolution, thus clarified, takes the name of *clairé* in France. When it is evaporated to the point wished for, they put it into the moulds; there is then separated from it a syrup, which they call *uncovered syrup*. Afterwards they cover it with potter's earth, or clay, which they moisten with water, and the new syrup which drains from it is known under the name of covered syrup. The sugar which is made from this first work is loaf sugar. If they cause loaf sugar to undergo a second refining,

there results from it sugar extremely white and firm, and which is known by the name of royal sugar.

Sugar is very soluble in water and in alcohol: it has a sweet and agreeable taste; it swells, blackens, and forms a spongy coal or charcoal; it gives out, in this last circumstance, a particular smell, which they call odour of caramel, or burnt sugar.

Sugar crystallizes readily. It suffices to dissolve it in water, and to bring the dissolution into the consistence of a thick syrup. The crystals have the form of tetrahedral prisms, terminated by diedral summits; this then is called sugar-candy.

The sugar-candy is obtained more or less white, according as the syrup has been more or less clarified. They can colour it as they will, by putting into the syrup a colouring substance that is soluble. Confectioners make the greatest part of their sugar-candies with the scums of syrups, and the remains of the same syrups, which they clarify with care. They can even precipitate crystals on small sticks, in such a manner as to clothe them completely.

Sugar is one of the vegetable products the most employed in our domestic habits: we not only make use of it to correct sourness, the bitterness or pricking of certain aliments and of several drinks, but it becomes also, in our hands, a very powerful means for preventing the alteration of animal and vegetable substances, which serves for our nourishment, and on this last account sugar is the most useful and the most profitable article we can use for preserving fruits, &c.

Brandy pure, or charged with the aroma of divers vegetable substances, forms the base of almost all the liquors which are employed as drinks: but these liquors are very heating; they irritate greatly organs little suited to their use, when they are not softened by sugar.

Vegetable infusions and decoctions could not be kept from fermentation, if sugar did not furnish the means to preserve them without alteration.

There is also parts in the vegetables which are very changeable or very volatile, and we know that sugar only can fix them.

In this case they mix the infusion or decoction with the sugar, of which they facilitate

the solution by means of the vapour bath and a gentle heat The liquor becomes syrupy; and, when it is cold, they pass it through white stamine (a light kind of serge): afterwards they inclose it in well closed vessels.

In order that the syrup may have the consistence requisite, it ought to mark 35 degrees by Baumé s areometer, when it is cold.

They employ generally 30 pounds of sugar to sixteen pounds of the infusion.

They make syrups sometimes from water distilled from aromatic plants. They differ from those of which we have been speaking, in that they contain only aroma, whilst the others preserve a portion of the extractive principle.

The proportions of sugar ought to vary, according as the liquor in which the dissolution is made is more or less thick.

They ought also to vary the degrees of heat, in proportion to the degree of volatility of the principle which they propose to preserve.

Syrups are either simple or compound, according as there enter one or more substances into their composition.

When they have approached very nearly to the dissolution of the sugar, it congeals by cooling; and it is in this state that they sometimes employ it, to put in and involve in it certain vegetable productions, such as fruits, rinds, &c. This is what they call dried comfits, or sweetmeats.

When they cause two parts of sugar to be dissolved in one part of water, and bring the dissolution to such a point that a spoon dipped therein and shaken strongly in the air, lets escape from it the layer of sugar, in thin slender pellicules, which was attached to the surface, they say the sugar is made *a la grande plume*. It is in the sugar made in this way that they dip the fruits, rinds, and stalks of certain plants, which they cause to boil again, in order to impregnate them better with the sugar, and to dry them more completely.

It is also by the means of sugar that they preserve the juice of certain fruits, and of which they make comfitures, properly so called.

The mucilaginous fruits, such as pears, apples, apricots, currants, quinces, are the only ones fit to produce jellies.

They confine themselves, in all cases, to

boiling the fruits with the sugar; and when they have carried the evaporation to a convenient degree, which they know by congealing a little of it on a plate, they then strain it through a sieve, and pour it into the pots.

They aromatize and give the pulp a flavour with cinnamon, lemon, or any other aromatic, according to the nature of the fruit and the taste of the preparer.

Sugar seems to afford a very wholesome aliment. Pringle has observed, that the plague hardly ever penetrates into a country where sugar forms the chief part of the nourishment of its inhabitants. It is an error to regard it as producing worms: this prejudice owes its origin, probably, to the desire which they have had to dissuade dainty children from its use. Insects and worms cannot live upon it; and when it is mixed with mucilage, they devour this last without touching the sugar.

SECTION III.

Of Mucilage.

The state of mucilage seems to form the first change of alimentary juices in vegetables.

We see that almost all the grains or seeds take a mucilaginous character, as soon as they begin to spring up, and that the young shoots of trees present only a pulp *.

Vegetable mucilage has the greatest analogy with animal jelly: the one and the other form the first rudiments of the composition of organic beings. Young animals, like young plants, present but a mass of pulp; and, in the two cases, we see the proportion of mucilage decrease, as the being gains strength and becomes older.

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* The class of resinous trees make an exception to this rule. In these last all begin by having the character of resins, and the mucilage which is there found seems only proper to dilute and aid the juice to flow.

From this superabundance of gelatine (or jelly) in the first age of the plant and animal, and its progressive diminution from age or time, we can easily deduce the causes of some diseases which are peculiar and proper to every period of life. We shall see bye and bye, for example, why cold congeals sooner the humours of children than those of adults; why these last are less subject to worms, and all the diseases which proceed from the gelatine; why young plants rot sooner than others, &c.

We find the mucilage almost alone in certain plants, as in the mallows, the grains of quince seed, those of lint, &c. Sometimes the mucilage is combined with substances insoluble in water, and which is maintained there in a state of emulsion, as in the euphorbium, the *convolvulus*, &c.

Mucilage is also found combined with some fat oils, with sugar, with acids, and with neutral salts, &c.

Mucilage forms sometimes the permanent state of the plant, as in the *tremella*, the *conferva*, some *lichens*, and the greatest part of mushrooms.

This permanent existence under the form

of mucilage is also observed in some animals, such as *the medusæ, the holoturiæ*, &c.

The characters of mucilage are solubility in water, from whence it is precipitated by alcohol, an almost insipid taste, the property of yielding, by heat, a spongy coal, and to burn badly and with little flame.

The mucilages employed in trade, with the exception of some which are used in medicine, are known under the name of gums; they distinguish three or four, viz. gum arabic, gum tragacanth, the gums of the country, &c.

The gums of the country ooze from trees in our own climate, such as the prune-tree, the cherry, the apricot, &c. They issue through the bark of these trees, and congeal into reddish tears upon the surface.

Gum arabic exudes from the acacia, in Arabia and in Egypt. It is found in commerce in round pieces, white and transparent, wrinkled exteriorly, and hollowed interiorly. This gum dissolves easily in water, and forms a transparent jelly, which they call mucilage.

Gum tragacanth is furnished by a shrub in the isle of Crete, which bears it name. It is

found in small white tears, twisted like little worms. It forms with water a jelly thicker than the gum arabic.

These gums are rarely found without mixture or alteration. But when they are to be used for delicate operations, they may be picked, in order to have them free from all impurities.

These gums can be easily ground and reduced to powder; when these substances are left to digest in cold water, it saturates itself, and becomes glutinous. Boiling water dissolves them more quickly. The saturated solution of the two first kinds preserves a remarkable fluidity; that of the gum tragacanth congeals. This last is preferred, in all cases where it is wished to obtain much consistence.

The use of these gums is very general in the arts.

1. They use them for glazing certain stuffs and hats. The solution of gum gives consistence, gloss, and lustre, to all kinds of wove stuffs, without injuring the colour: it fills the interstices which is left between the

threads of which they are composed, and gives to the stuff an appearance of strength and goodness which it otherwise would not have.

These stuffs lose their gum by rain or by washing. When the rain falls unequally on the stuff, it forms thereon spots, in consequence of the gum not being entirely washed away; and it is to prevent this inconvenience that it is customary to take the gloss out of a new coat before it is exposed to the rain. The most part of the stuffs glossed with gum, and cylindered, have to the eye, at first sight, a shining and icy look, which to be agreeable ought to be uniform. They employ at present cylinders of paper for extending cloth; they have the advantage over metal ones, in giving to the stuff a tufted velvet-like appearance, which could not be produced by metal cylinders. Another inconvenience which results from gumming, is that, when the hand is applied constantly on the same part of the stuff, the gum comes off: hats and lutestrings are particularly liable to this inconvenience.

2. They cover writing-paper with one layer of gum, to hinder it from imbibing the ink:

drawing paper differs only from this last in not being gummed.

When the paper is scraped, to take out any spot of ink, or to take out any words of writing, it is necessary to sprinkle the part scraped with dry pulverized resin, in order to dispose it to receive anew the writing.

In most of the paper manufactories, they glue the paper with a glue which is made from the parings of skins and parchments.

3. Mucilages serve for the base, or *excipient*, to all the colours which are applied by impression, in the numerous fabrics of painted cloths.

It is also made the base, or *excipient*, of many colours which is applied with the pencil.

4. Gum forms the base of almost all the blacking which is used for shoes, boots, &c.

In order that the blacking may have the requisite qualities, it is necessary that it should unite the following properties: to spread easily, to dry quickly, not to be scaly, not to crack, neither to dry too much, nor burn the leather, to resist friction, and to possess an agreeable brilliancy.

Oily bodies, such as the oils and spermaceti, preserve leathers, and give them suppleness. Oils render them pitchy and tarni hed; and greases form after some time dirty plasters, from the difficulty of removing them.

Ink, and all preparations of this kind, burn leather, and do not shine.

Eggs beaten up with soot, gives, for the moment, a brilliant coat; but the surface of the leather becomes covered with small scales, which fall off by degrees.

Gum alone, dissolved in water, forms a good blacking; but it has the inconvenience of drying slowly.

But, if the solution be made with proof spirit, the defect of its not drying sufficiently quick is corrected, without causing the gum to lose any of its properties. To form a good blacking, mix a dissolution of gum with a strong decoction of logwood; add the alcohol and sugar as usual; a terwards pour into it a solution of sulphate of iron.

5. Gum is also used in medicine, where mucilages are ordered, on account of their softening and calming qualities. They are also the base of many other remedies. Mucilage of

lint-seed, and that of quince kernels, are those to which the preference is constantly given.

SECTION IV.

Of Feculæ.

Chemistry knows, under the name of feculæ, a vegetable principle, heavy, insoluble in cold water, in which it precipitates to the bottom, and forms glue with boiling water.

This substance circulates in the plant by the aid of the mucous principle; it precipitates itself, and forms a depositum in the water, as soon as by any means this principle is destroyed or dissolved.

The fecula preserves a certain tenacity, and a kind of transparence, as long as it is humid; but it becomes pulverulent, and forms a fine powder the moment it is dry.

When the finger is run along a light layer of humid fecula, with a gentle pressure, its crackling noise is heard like to that which is produced by silk or salt-petre when pressed in the hand.

There are very few plants that do not contain fecula. M. Parmentier has analyzed a great number of them, with the intention of extracting the fecula, and has found this principle in almost all; but the gramineous seeds, and the bulbous roots, furnish the most.

Water and fermentation are the only agents employed for preparing feculas.

I. *Of the Extraction of Feculæ by Water.*

When a plant contains fecula, in order to extract it, it is sufficient to grind it to break the texture of the fibres, and to throw water lightly on it.

The fluid dissolves the mucous, and draws with it the fecula, which precipitates by rest.

The analysis of the flour of the *graminous plants*, by the aid alone of cold water, furnishes us with a striking example It suffices to form a paste with the flour and water, and to knead them between the hands and under water: in proportion as the mucous and the sugar dissolve in the liquid, the fecula dilutes, whitens, and is not long in precipitating; there

rests then nothing in the hand but the portion of gluten, or the vegeto-animal matter, which the flour contained.

It often happens that vegetable juices are so fluid as to carry out the fecula which is therein contained: in this case, we confine ourselves to tearing the plant by mechanical means, in order to submit the pulp to a strong pressure. The juices which run off, are white and milky; but gradually they clarify by the deposition of the fecula, which we must afterwards wash, to separate from it all the impurities which might have remained.

This method, although employed in certain cases, cannot be looked upon as very economical, because it furnishes but one part of the fecula which is contained in the plant.

The preparation of the fecula (or meal) of potatoes is made by a more rigid method, and preferable in every respect.

They wash the potatoes carefully; they are ground in mortars or under cylinders, otherwise they grate them. The pulp is put into a hair sieve placed upon a tub, and they wash them with a great deal of water, constantly stirring them, until the water passes clear.

The water of these washings deposits, by degrees, the fecula which it carried off with it. They decant this water; they wash at different times the fecula, until it be deprived of every foreign matter it contained.

The fecula of bryony-root might be prepared in the same manner; but, in general, they pursue the following method: they peel the fresh roots of the plant; they grate them, and they submit the pulp to the press, after having inclosed it in a strong linen bag. In twenty-four hours there is formed a deposit of fecula, which is separated by decanting with care the portion of the juice which is uppermost. This fecula is purgative in this state; but it can be deprived of this virtue by repeated washings, which bring it back to a fine degree of whiteness. The residue which remains after the expression, contains more fecula, which is not purgative, and which can be extracted by water. Beaumé has proved, that the fecula of bryony did not differ from the starch found in trade.

Sword-grass, *arum*, (or *wake robin)*, and the Indian chesnut, furnish a great deal of fecula; and it is perhaps of some interest for society, to direct the attention towards this

object, because there may be found occasions where the meal of the *gramina* is entirely demanded for our subsistence.

That which is called *sago*, is only the fecula which they extract from the old palm-trees in the Molucca islands. It is commonly in small grains, which are diluted in warm water, so as to form a very nourishing mucilage.

It is also customary to prepare that which is called *salop*, by taking off, by decoction, the extractive principle from the bulbous roots of all the kinds of satyrion *(orchis)*, and in drying the residue in the air, or in stoves.

The cassave bread of the Americans is extracted from the root of the manioc: they peel it, then rasp it, and they procure, by pressure from the pulp, a sharp biting poison, which very soon deposes the small part of the fecula which the juice has carried off with it. The pulp, freed from the venomous juice, and slightly roasted on hot bricks, affords the cassave bread, which is the most common food of the negroes.

Custom has prevailed in calling *amidon*, (or starch) the fecula which is extracted from the *gramina*. Wheat is that, of all the grains,

which furnishes the finest, and in greatest quantity. It is difficult to take from barley a pitchy matter which opposes itself to the precipitation of the fecula: oats and rye yield so little starch, that they are not employed for this purpose.

Starch can be extracted from wheaten flour by the means of washings in cold water. It is sufficient, for that, to knead carefully the paste in the water; the starch very soon whitens the liquid, and precipitates.

They practise also another method, by which starch is extracted by the aid of water. To effectuate this, they put very good wheat into casks filled with water, and one of the heads stove in, and expose them to the sun; and they change the water twice a-day, taking care to stir the grain well, so that it may be completely washed. They leave the grain to steep until it crushes to pieces easily between the fingers: eight days generally suffice to obtain this effect. When the grain is arrived at this state, it is put into clean linen bags, but strong; and they press the grain between two planks, steeping, from time to time, the bags in water, in

order that the liquid may carry with it all that comes out by the pressure.

As soon as the water becomes clear, they withdraw the residue, which they preserve in a cask, to be afterwards treated by fermentation. It furnishes some more starch, but of a quality inferior to the first.

The starch obtained by this method, must be washed with care, in order to purge it of all that is precipitated with it. They can give to it, by frequent careful washings, a degree of whiteness which that obtained by fermentation cannot acquire.

II. *Of the Extraction of Fecula by Fermentation.*

Hitherto we have confined ourselves to disorganize the vegetable by mechanical means, in order to extract the fecula; and we have employed water in preference to all other liquids, on account of the well known property that it has of not affecting the fecula, and of dissolving the mucilage with which it is commonly united. But if this method presents

some advantage by its simplicity, and the beauty of the production which it furnishes, it offers also some inconveniences; that, for example, of yielding only one part of the fecula which is contained in the plant. It is, without doubt, this last consideration that has engaged artists to pursue other methods; and they have arrived at a way to separate all the fecula of a vegetable, by means of a light and limited fermentation.

They distinguish, in trade, two kinds of starch, fine and common.

As the fermentation necessary to the fabrication of starch, cannot take place without the use of an acidulated water, which is called *sour water*, they prepare this water in the following way: By diluting two pounds of bakers' leaven in a bucket of hot water; it is then left to settle for two days, after which they add some buckets of hot water. It is left again to settle for two days. This time ordinarily suffices to turn the mixture, and the sour water is then found quite prepared.

MM. Parmentier, Deyeux, and Vauquelin, have procured from the analysis of sour water a small quantity of alcohol, and much acetic

acid; and M. Vauquelin has found in it a little ammonia and phosphate of lime.

The small quantity of ardent spirit arises from the fermentation of the sugar of the flour with the leaven; and the acetic acid has been formed at the expence of a little starch. So M. Vauquelin has observed, that the proportion of starch was greater before than after the fermentation.

When they wish to extract starch, they put a bucket of sour water into a Burgundy half pipe, unheaded at one end. They fill the cask with water to the bung, and they finish by filling it with the flour which ought to yield the starch.

They leave this mixture to macerate during ten days in summer, and fifteen in winter.

They discover that the fermentation is sufficiently advanced when the matter precipitates, that the uppermost part of the liquor is clear, and that there is collected on the surface a kind of foam, which they call *fat water*. They throw off the water and the foam.

They place upon a proper cask a hair bag of 20 inches square, and they pour into it the deposed matter; and they wash it carefully, by

passing repeatedly on it pure water, until that it no longer whitens the water. There then remains nothing in the bag but the bran, which they preserve for the use of the cattle.

The milky liquors which have run into the cask, subside gradually; and at the end of two or three days, they pour off the water from above it, and they preserve a part of it for sour water in the subsequent operations.

In order to have very fine starch, they wash the sediment in clean water, and they leave the matter to settle for two days. In this interval there is formed a considerable sediment, which presents three very distinct layers.

They decant the water which covers the sediment, and they take up with precaution the first bed or layer, which they call the *first white*. It is only composed of the breakings of the bran, which, by reason of their fineness, have passed through the fibres of the bag. This matter is commonly used for fattening hogs.

They proceed afterwards to the extraction of the second layer, which they call the *second white*. They dilute it with warm water, in or-

der to purge it of all the foreign matters that it contains: they leave it to depose. It forms common starch.

Finally, under these two layers there rests a third, which constitutes the finest starch. It must be washed with care, in order to present the whole of the properties that characterise it. They even filter it when it is diluted in water, through a silken sieve, in order to retain that which might have escaped from the hands of the workman.

When the starch is well washed, they take it out of the cask and put it into ozier baskets, lined with linen, in order that it may lose its first humidity.

As soon as it has acquired consistence requisite, they divide it into two parcels, and dry it in the open air.

They scrape the surfaces of that which is the least white, and that which is detached they mix with the common starch; they break the remaining pieces, and they finish the drying in an oven, where it is frequently stirred. The heat of the sun is preferable, when it is sufficient.

The use of sour water in this operation, seems to be confined to preventing a putrid tendency on the part of the flour. It moderates the movements of the fermentation, so that there is a disunion of principles, rather than a destructive fermentation.

Feculæ serve a great many purposes in the arts.

1. They make sizes, which are much used, from their being known in almost every workshop, and from being the principal ingredient of several professions.

2. Size, coloured by a little blue, forms the starch which they use for giving to linen and to some stuffs gloss, stiffness, strength, and an agreeable look.

3. Starch bears also the name of hair-powder, from its being made use of for this purpose.

4. It serves to give lustre to many kinds of stuffs.

5. The feculæ form a very nutritive aliment. They employ for this purpose sago, salop, and the fecula of the potatoe, &c.

In some northern countries, *lichens* form almost the only food of man, and animals that

are not carnivorous. Lichens yield, by simple grinding, an excellent starch, according to the experiments of the Stockholm academy.

SECTION V.

Of Gelatine.

The jelly which abounds in animals, has some analogy with the mucilage of vegetables: like it, it seems to form the first degree of alteration in the alimentary juices; and, like it, it is soluble in water, and forms with this liquid, when it is saturated, a half transparent jelly.

But animal gelatine precipitates with tannin, whilst mucilage does not contract with it any combination. This character, were it the only one, would suffice to establish a very great difference between these two productions.

Young animals are nothing almost but a mass of jelly: in this mass of pulp, the divers parts that ought to compose the animal, form

and develope by degrees; and it is seen that the fibres form themselves insensibly from the coagulable lymph and the phosphate of lime.

There are parts in the animal which preserve the permanent state of hardened jelly: such are the ligaments, the membranes, the cartilages, the skin, the horns, &c.

Thus, gelatine composes not only the first principles of the animal, but it forms also its permanent state.

When, by a prolonged boiling of animal matter in water, they have extracted all the jelly, the insoluble residue is, in general, very little; and, if they boil animal substances which contain the most, the decoction is seen to congeal in cooling, and to form a solid, tremulous, and half transparent mass.

These jellies are served as aliments on our tables, and are excellent. They whiten them with the milk of almonds, and they colour them with saffron and other colouring principles, in order to vary the colour and the taste.

Jelly at this state of consistence putrifies readily, and yields much mephitic air in its decomposition.

If they make the jelly so as to give it a solid consistence, and take off, by a suitable drying, all the water, they take from it the faculty of putrifying, and they form it into small cakes, which are only the extract of the nutritive principles contained in the jelly.

These cakes, or portable soups, may be prepared by the following method. For this purpose they take,

Calves feet	4 lbs.
Bullock's thigh	12
Veal in slices	3
Leg of mutton	10

They boil meats on a gentle fire, in a sufficient quantity of water, and skim it as usual. They strain the soup with pressure; they cause the meat to be boiled a second time in another water; they mix the liquors, and leave them to cool, in order to separate perfectly the grease: it is then clarified with five or six whites of eggs; a sufficient quantity of common salt is added; the liquor is passed through cloth; and they evaporate it to the consistence of a very thick paste. Then it is spread on a smooth stone, and cut in tablets. They

finish the drying in a stove, and shut it up in bottles, which are carefully stopped.

Fowl and aromatics can be put into the composition of the cakes.

When it is wished to make use of these cakes, they dissolve them in hot water.

The cakes of *hockiac* which they prepare in China, and that are known in France under the name of *asses' skin glue*, are made with animal substances.

If they employ those parts only of animals that are formed entirely by the thickened jelly, dissolve them in boiling water, and bring the dissolution into the consistence of cakes, they form that which is called *animal glues.*

There is known in commerce three or four kinds of glues, which have received different names, as much on account of the differences which exist between them, as on account of the divers animal matters from whence they are extracted. We shall only speak here of the principal ones.

I. *Of Glue.*

Glue can be made with the shreds or parings of skins and leather, the feet, the skin, the head and the tails of some animals, and with the bones themselves.

Tanned leathers do not yield glue, because that the jelly is there combined with tannin.

Leathers dressed with alum and tallow yield but little, and that of an ordinary quality.

The clippings of camels skin dressed in oil cannot be employed.

The hair does not dissolve: blood, grease, and flesh alter the quality of the glue.

The parings of vellum and of parchment make good glue. The skins of the hare, rabbit, and beaver, of which the furs are taken off, may be advantageously employed.

It is well known that old and lean animals yield a better glue than the young and fat ones.

Painters in water colours, clothiers, and paper-makers, prepare the glue that they have occasion for without drying it. They boil in

water the parings of skins and of parchments, the unfurred skins of the rabbit, hare, beaver, &c.; and when they perceive that the decoction can congeal by cooling, they stop the operation, and employ the glue in this state.

But in the manufactories where they prepare glue for commercial purposes, they proceed to its fabrication by a series of manipulations, all well combined.

They begin at first by steeping the matter in large tubs: twenty-four hours suffices for fresh skins; more time is requisite for dry skins: they stir them from time to time, in order that they may be completely imbibed. They are taken out of the water as soon as they are well soaked, and placed upon hand-barrows, where they drain. They are afterwards carried to the river, to be there well washed: for this purpose they are put into open cages, which are placed in the water: they stir and agitate them with a long-teethed rake. The cage is raised out of the water by the aid of a sweep, in order that the leather may drain: it is replunged into the water; it is taken out; and they repeat this operation until the leathers are clean, and the water runs off clear.

They wash separately the different kinds of leather, because they do not all demand the same care. The ears, for example, require more time and much more attention, because the filths there are more tenacious than elsewhere.

When the skins are very clean, they put them to steep in weak lime-water. They may be left there for a length of time, in order that they may be well soaked; but they take the precaution to refresh them, every fifteen days, with a bucket or two of new made lime-water, and they turn the skins from time to time.

This lime-water dissolves all the grease, detaches all that which adheres to the skin, and converts it into a state nearly of parchment.

When the skins that are employed have yet their hair, they put them into a stronger lime-water, to cleanse them: they do the same for those that have been dressed by alum and tallow; and they treat by a similar method, all matters that contain much grease, blood, and synovia. It is in this first operation that the cuticle is dissolved, which cannot be attacked by water only.

The skins are afterwards put to steep in clear

water; they drain them on the hand-barrow, and they are washed at the river with the same care as the first time.

There are manufactories where they pass under a press the skins thus cleaned, in order to press out all the water which they contain.

To these preparatory operations succeed the dissolution of the matters, which is generally done in a large copper kettle. Some put stones in the bottom of the kettle, in order to prevent the skins from sticking to it, and burning; others place a wooden grate, which produces the same effect.

The kettle is filled until it runs over, and there is added more or less water, according to the state and quality of the matters.

They light at first a small fire, to dissolve the matters by degrees. The fire is gradually augmented until ebullition takes place; and in proportion as the glue is made, some diminish the fire, and do not stir it; others stir the matters until the glue be made, and feed the operation during twelve or fifteen hours.

They judge that the glue is made, when, on pouring it upon a plate, it is known to have

the consistence requisite. In this state it is run into a tub, upon which they have placed a long and square cage, which is called *hand-barrow*, and of which they have garnished the bottom with a bed of long straw. The melted glue is poured upon this straw, through which it filters and falls into the tub. This operation ought to be quickly done, and the place where it is done ought to be warm, in order that the glue may not congeal. They take care even to cover the hand-barrow and the tub with cloths, to prevent its cooling.

The glue is left to refine in the tub during three or four hours, and it is taken out while still fluid, to be put into wet wooden boxes, where it congeals.

When it is wished to obtain divers qualities of glue, cocks are placed at different heights of the tub. The glue is made to run by opening these cocks successively, beginning by the superior. That which flows out the first is the purest; the last is but the inferior layer, and contains all the impurities which are precipitated.

The glue is left in the boxes during twenty-

four hours, after which it is taken out, to be divided into cakes. These cakes are taken to the drying place, which, in general, is a cart or coach-house covered, the sides of which receive the air from all quarters.

When the glue is half dried, they pierce the sheets at one of the ends to pass a small cord, and to arrange them in the manner that they are found in commerce.

When the cakes are almost dry, if they wet them a little, and rub them with a piece of new fine linen, they give them transparency and a fine polish.

Although in general, in manufactories of glue, they use only tendons, cartilages, the ears, and parings of old animals, they can employ bones with advantage. M. Duhamel has already extracted glue from them; and he has proposed Papin's digester to boil them in. MM. Parmentier and Pelletier, having been requested to ascertain the truth of these results, ascertained that six pounds of bone shavings taken at a button-maker's, and boiled in twenty-four quarts of water, until it is properly made and brought together, can yield—

	lb.	oz.	drs.
Glue transparent . . .	0	15	4
Glue impure	0	0	4
Residue dried	4	3	0
Loss	0	13	0

Six pounds of ivory shavings furnished them with—

Glue	1 lb.
Residue	4
Loss	1

These are the glues which are most esteemed by cabinet-makers and joiners.

The use of glue, become so general in the trade of the joiner, &c. has two inconveniences: the first is that of drying in such a manner as to permit the separation of the blades which it glued together: this is what is observed in almost all cabinet-makers' furniture, of which the pieces loosen and fall off by the smallest stroke. The second inconvenience, is that of being soluble in water: it is this that hinders its use, except for works that are sheltered from this liquid.

The first of these two inconveniences is ob-

viated, by employing only good materials for the composition of the glue, and above all, in not forcing too much the decoction.

The second can be remedied, in causing the glue to melt with the least water possible, and in adding to it, by degrees, dried lintseed oil, and in stirring the mixture, that the two matters may be well incorporated. Afterwards it is dried, and they have a glue that does not dissolve in water.

II. *Of Flanders Glue.*

This glue differs but little from the preceding. In place of employing in its fabrication the parings of old animal skins, they use the clippings of sheeps' skins, lambs' skins, and other young animals, as well as those of parchment.

These matters are carefully washed; the glue is left a long time in the tubs, in order that it may depurate; and it is put up in leaves (or cakes), very thin, which, from that circumstance alone, causes it to appear more trans-

parent. They give them only a line of thickness in the middle.

This glue has commonly a whitish colour. The painters in water-colours, clothiers, and paper-makers, prefer it to common glue, because it is less liable to become scaly in drying; besides, it changes less the colours.

Joiners, inlayers, &c. who have occasion to fix pieces of wood with the greatest possible solidity, prefer common glue. With them transparence is a useless quality.

III. *Mouth Glue:*

They give the name of *mouth glue*, to a new preparation of the one and the other of the foregoing glues, which allows of being dissolved in the mouth, and instantly employed.

They take generally of the very finest common glue, which they break into small pieces, and which they soften by steeping it in cold water for two days. They decant the water that swims above, and they melt the softened glue with a gentle heat. When it is very fluid, they incorporate therewith half its weight of

ground sugar, of which they assist the dissolution by a continual movement.

They run this dissolution on a marble that has been rubbed with a linen cloth imbibed with good olive oil This plate is left to cool and congeal for four or five days: it is then extended on a towel doubled into four; it is covered again with another towel, and the whole charged with a plank on it. By this means it is not only flattened and rendered more compact, but all the oil is pressed out that it might have taken up from the marble. This pressure is renewed; and they cause the towels to be warmed. in order to produce more speedily the effect that is desired. It is then cut into small tablets or plates, of one line (2,25583 mill.) of thickness by eight to nine (18,04664 mill) of breadth, and about three inches (8,1210 centim) of length. The e little cakes are dried in replacing them between hot cloths, and loading them as before: this is repeated until the glue is dry and brittle.

IV. *Of Calves'-Feet Glue.*

There are manufacturers that put calves' feet into the composition of Flanders glue. But when they are employed alone, a clear and transparent glue is obtained; which, without having much strength, has nevertheless its uses in the arts.

They begin by taking off the hair in boiling water; then the bones and all the slimy parts are separated; they boil the remains in water, and scum it with care; and when the cooled decoction can put on the consistence of a thick jelly, they pass the glue through a linen cloth, and leave it to cool slowly.

This glue is very transparent; but, as it is inferior in virtue to English glue, or that of Flanders, it is but little made use of.

V. *Of Glove and Parchment Glue.*

Glove glue is made from the clippings of white glove-skins, which are made to boil in

about eighteen times their weight of water, until it is reduced one half, stirring them constantly with a stick.

It is thickened more or less, according as it may be desired.

Parchment glue is made in the same way: it is stronger, but less white.

Gilders in burnished gold employ much of these two glues. They make also a glue with eel-skins and a little lime; they strain the decoction, and add to it some whites of eggs. They apply the gold upon a layer of this glue.

The paper-makers make use of a glue nearly similar: they put the clippings of the skins into an iron cage, suspended in the midst of a kettle full of boiling water; and they know that it is at the wished for degree of strength, when the spittle no longer penetrates the paper that they have glued. They have observed, that it was more expeditious to put the skins into boiling water, than to put them immediately into cold water, which is brought by degrees to ebullition.

VI. *Of Fish Glue.*

The Russians prepare fish glue, known under the name of *isinglass*, with the air-bladder of the sturgeon.

The bladders of *sterlets* furnish the strongest glue, and they are preferred to all for inlayers' work.

They steep the bladders in fresh water; they turn them, and cut them lengthwise in bands, which they spread on large leaves in order to dry: they strip them of their first skin: they are rubbed in order to detach the cuticle; that done, they roll into all forms, the white and shining skins, and they dry them anew.

Along the Oka, where they only dry the sterlets, they take the bladders of these fish; they beat and dry them.

They prepare for the same use, that of the *glanis*, on the borders of the Volga: this last is much esteemed for cabinet-makers' work.

Glue can also be made from the bladders of the barbel.

In the neighbourhood of Sinbirsk, and along the Volga, they make, by boiling the fresh bladders, a very fine glue, which they run into moulds.

When they wish to make use of fish glue, they beat it with a hammer, and cut it afterwards into small pieces with the scissars: it is put into water, where they keep it in a gentle heat until that it shall be melted. Wine or spirits may be employed to dissolve it.

This glue is of great use in lustring ribbands, gauzes, and for clarifying wines.

SECTION VI.

Of Tannin.

Tannin belongs essentially to vegetables: it forms their astringent property; but it has nothing in common with the mineral substances that are called styptic, such as alum, copperas, &c.

Tannin forms one of the principles of all astringent vegetables; it abounds in *catechu* (Japan earth), the barks of the oak and the pomegranate, galls, sumach, &c.

It is soluble in water, and it can be extracted from the vegetable by the means of this liquid; but then it is mixed with different products, which are foreign to it, and which it is of importance to rid it of, in order to leave it pure.

M. Proust has made known to us a method sufficiently simple for obtaining the tannin in all its purity: it consists in pouring a solution of the muriate of tin into a decoction of gall-nuts: there is instantly formed a precipitate

of a white yellow colour, which is only the combination of the astringent principle with the oxide of tin. They decant the liquor that swims above, and wash the precipitate: it is diluted in water, and it is decomposed by means of sulphuretted hydrogen gas. The sulphuretted oxide of tin deposes, and the astringent dissolves by degrees in the water. It is filtered and evaporated in a silver bason: the solution takes the smell and the colour of a decoction of galls. The substance left after the evaporation, is dry, brown, friable; it has the brittleness of extract of aloes, and does not attract moisture from the air: it has a sour taste, and dissolves again in hot water and in rectified spirit.

If, in place of employing the decoction of galls, they use that of tan (powdered oak bark), the precipitation takes place by the nitro-muriate of tin. But, when it is well washed, it is no more decomposable by the sulphuretted hydrogen gas: it does not even change colour. This proves that the astringent of the galls is modified by the gallic acid.

Tannin can be extracted by rectified spirits, and by ether.

It is dissolved also by heat, and by fixed or volatile oils.

The tannin is precipitated from its watery solution by almost all the known acids: the muriatic, oxalic, tartareous, phosphoric, pyroligneous, form with it a precipitate of a pale red cinnamon colour. The precipitate by the sulphuric acid is of an orange colour, and the heat that is produced in the operation, gives out a very remarkable smell of tan. The nitric acid precipitates the least: the acetic and benzoic acid do not precipitate it, until after a long time: the oxygenated muriatic deposits it in grey, and discolours the precipitate.

Potash blackens the solution of tannin, and precipitates it; soda produces a less sensible effect; and ammonia yellows the colour, and precipitates it more slowly.

Tannin not only takes up earths from their solvents, but it combines itself with them when they are pure: if lime is mixed with a watery solution of tan, there is instantly formed a yellow precipitate. Magnesia, alumine, barytes, form with it particular combinations.

Tannin deprives also metallic oxides of their

acid solvents. The oxide of iron forms with it a precipitate of a brown green, when it is acted upon by the sulphate; that of lead, in the acetate, is precipitated in a residue of the colour of coffee; that of copper, in the sulphate, in green; that of tin, in the nitro-muriate, in yellow; that of zinc, in the sulphate, in a dirty grey; that of mercury, in the nitrate, in grey very abundant. The precipitates of silver and mercury are, in part, brought back to their metallic state, according to the observations of the Academy of Dijon.

Tannin separates resins from alcohol.

But the principal property of tannin, that which has given so great an interest to this substance, is the faculty that it has to combine with the jelly, and to form with it, in water, an insoluble and unputrifiable body. It is above all to M. Seguin that we are indebted for this important discovery, and the happy application which he has made of it to the theory of tanning.

Tannin is almost indecomposable by fermentation. It seems even that the fruits and barks that contain the most, are those which keep the longest.

A very fine experiment of Mr. Hatchet's, which consists in forming the tannin by the solution of any charcoal in the nitric acid, has thrown great light on the nature and properties of this substance. It seems, in effect, after this, that the tannin is only an oxide of carbon; and, in setting out with this principle, its inalterability, and its existence in barks, is easily understood.

END OF THE SECOND VOLUME.

J. Adlard, Printer, Duke-street.